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TECHNOLOGY/FIXED BROADBAND

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P R O C E E D I N G S

MR. KNAPP: May I have everybody please take their seats and the panelists come to the front table? I'll give you just a minute to get settled. Good morning, everybody. I'm Julius Knapp, I'm with the Office of Engineering and Technology. Thank you for coming today. We had three sessions yesterday that were just fantastic, so they set the bar really high. And I know we've got a great group of panels and speakers today, and so I have every reason to expect it's going to be at least as good.

This morning's session is going to focus on fixed broadband deployment. For a long time, you'd think of fixed as being wired things, but actually now wireless can also offer fixed services, so we've got a combination here.

Just a couple of quick ground rules, a reminder to please turn off your wireless devices so that we don't have interruptions or feedback. We've got, for each of the panelists, five minutes allotted for a presentation that will be followed

by questions from the Commission staff and from folks over the internet or the audience. So with that, unless there are any other questions, we'll get ready to roll. Victor, if you could start with the first presentation.

DR. FROST: Sure.

MR. KNAPP: Thanks.

DR. FROST: Yeah, I wanted to start out by, thank you for providing me the opportunity to participate today. I'm from the National Science Foundation, and just to set the stage a little bit for background, NSF has a mission to support basic, scientific, and engineering research. The Foundation's activities support discovery, learning to cultivate a science and engineering work force and the development of research infrastructure.

Within the Foundation, I'm with the Computer Information Science and Engineering Directorate called CISE. The goals of CISE are to provide leadership and research and understanding of the principals and uses of advanced

communications and information systems in the service of society.

CISE's approach to achieving these goals is to support investigator initiated research in all areas within its portfolio. The Directorate also serves to maintain cutting edge national computing and information infrastructure to support research and the education of the next generation of computer scientists and engineers. So, clearly, research within the National Science Foundation and CISE plays a role and contributes to the networking broadband technologies that are being discussed today. We're all aware that over the years, communications technologies have moved from hundreds of bits per second to gigabits per second, and we're seeing several trends that are emerging that may impact our future as much as the increase in raw data rates.

One of those is, we expect the emergence of radios operating in very high carrier frequencies, enabling inexpensive gigabit per second rates. These radios will be ubiquitous and

their impact is yet to be determined.

Mobility, access to entertainment and information on the go is going to continue to shape the technology landscape. The line between fixed broadband and traditional mobile communications may be blurring. Today some people are using 3G technologies for their home internet, and this trend may increase as we move from 4G and higher wireless rates.

We're aware that the FCC recently permitted shared access of white space in the TV spectrum. So in the not too distant future, it's going to be possible to build cognitive networks out of cognitive radios. By learning the characteristics of the local environment, these systems will be able to optimize the use of scarce resources, for example, spectrum. And cognitive networks has the potential to be one of those disruptive technologies as time moves on.

We're also seeing the emergence of cloud based applications. These are applications that reside and run in the network. Some people just

call this cloud computing, but it has the potential to be broader than just computing.

Here the ultimate consumer device may evolve to something that just enables media output and user input, and applications may be selected and executed like you select a TV channel today.

We're also likely to see the emergence of new content, for example, providing real time experience using video. This content will raise new issues, some technical, but most not. We'll be challenged to find some ways of managing the associated traffic to maintain user experience. And here the QOS issues may arise to support to content, new business models may evolve beyond the current internet flat rate, for example, selling content application bundles more like in the cable TV industry. The last trend I'd like to mention is virtual networks. We talk about virtual machines, virtual memory, virtual links, now we can talk about virtual networks. A key attribute of virtualization is that each user has the impression that they are the sole user of that

particular resource.

It's important to realize that virtualization may provide an opportunity for diversity of networking architectures to evolve and simultaneously exist. Virtualization also has the potential to be another one of those disruptive technologies.

So cognitive networks and virtualization are significant emerging concepts, and these are two that the FCC maybe want to consider to develop an understanding of while they and how they impact the future of developing a national broadband plan.

Since it looks like I have about 30 seconds left, just a couple of comments in terms of some of the research that NSF is conducting now. The internet -- current internet architecture has been able to scale in terms of speed, distance, and the number of users. However, the evolution of the network, the current trajectory of incremental changes may not support the needs as we move forward. NSF is involved in

innovative and creative multi disciplinary research to design and evaluate new trustworthy architectures for the internet. There are several programs underway in that particular area.

One more aspect I would like to mention is that computer scientists and engineers need an experimental infrastructure upon which to test out their new services, networking architectures, and technologies. And toward that end, NSF has been supporting the development of a new network research infrastructure called the Global Environment for Network Innovations, it's called GENI.

So within CISE, there's many research programs that are addressing significant communications, information systems and networking, research problems. And I want to thank you again for the opportunity to participate in the important discussion today.

MR. KNAPP: Thank you, Victor. Adam.

(Pause)

MR. KNAPP: Bill, are you on the

network?

MR. ST. ARNAUD: Okay, yes. Good morning, everybody. I assume you can hear me okay?

MR. KNAPP: Yeah, we're fine.

MR. ST. ARNAUD: Okay. Well, first of all, I'd like to thank FCC staff for inviting me to just give a short talk at this event tonight. I applaud your initiative in this area. I think the work you are doing, looking at the challenges of broadband, will not only affect the U.S. national strategy, but other countries in the world, as well.

So I'm Bill St. Arnaud, I'm the Chief Research Officer for CANARIE, which is the Canadian equivalent of Internet 2, and it's a bit broader than Internet 2 in that we have been taxed with Canada's telecom internet strategies, networks, and applications. But we do work very close with Internet 2, National Lambda Rail, National Science Foundation, Educause, and various U.S. institutions like the University of

California San Diego.

As everyone knows, the internet really started with the R&E community, funded through the NSF. Not many people realize that the R&E community also has an important role and has been a major -- architectures and business models. The R&E community has long experienced and operated their own networks, both on a national and regional basis, and many university networks are equivalent to those that we've deployed in a small city. So we have a lot of practical experience in operating and deploying next generation type networks. And new broadband concepts, like condominium networks, customer control networks, hybrid networking, all have started with this community, are not slowing spreading into commercial deployment. So I think it's very important that we recognize the important role that the R&E community can play in this national broadband strategy.

Now, in my opinion, one of the biggest challenges we face in terms of a national

broadband strategy is developing the business case. Many people think that the government is going to invest billions of dollars in national broadband deployment, like we've seen in Australia.

But in this era of trillion dollar deficits, near bankrupt state and municipal government, I very much doubt that governments will have the capability or the wherewithal to make any significant investments in broadband.

So we really have to look at the private sector as the primary vehicle for deploying broadband, particularly next generation access. But even there, the business case for deploying broadband is also very weak, especially if you want multiple facilities based competitors. I think there's a general agreement among policy-makers and other people that facilities based competition with multiple providers is the ideal solution, if we can achieve that, because competition drives innovation, lower prices, and more choices for the consumer.

But the business case for the next generation broadband, even on a monopoly or duopoly basis, is also very weak at this point in time. And the big challenges are, of course, revenues from triple play are going to be declining as more and more services are deployed over the internet, between voice and video and broadcast TV and so forth.

Tape rates are a problem, and even with, you know, monopoly type applications, Verizon FIOS, for example, says they only can reach maybe 40 percent of their target market, and it's all predicated on a very high take- up, and revenues typically are about $130 per month.

And so these are really challenging numbers just for a single monopoly or duopoly situation. Trying to stimulate multiple competitive providers is going to be very difficult, if not impossible. So what we believe we need to do is to work with the R&E community, experiment with new business models and architectures, they'll try to solve this

conundrum. The next slide, please, if my slides are up there. Now, there's already some good examples of this. For example, some analysts, Derek Slater and Tim Wu at Google have been promoting an idea called Homes with Tails, and this is where the customer owns the last mile, and so there's been some discussion about that.

An initiative we have in Canada, and now undertaken in several other countries, is something we call Green Broadband, and that's to bundle the cost of fiber deployment and internet service with the consumer's energy bill.

This allows -- the consumer is encouraged to reduce energy consumption, but also provides a very steady and predictive revenue stream to the service provider, which is not predicated on triple play.

Now, both of these things are very experimental at this point in time and unproven, but I think this is the type of thinking we need and experimentation to look for alternate solutions for deploying broadband. A couple other

good examples --

MR. KNAPP: Bill, could you wrap it up maybe in the next 20 seconds or so?

MR. ST. ARNAUD: Okay. A couple other good examples are KPN in the Netherlands, working with Reggenfiber and condominium fiber, and Swisscom working with utility companies in Switzerland. So the bottom line is that we believe that working with the R&E community, we've got to experiment, find ways -- fund new models in deploying broadband architecture that address some of these problems. Thank you.

MR. KNAPP: Thanks very much, Bill. Now on to Adam; sorry.

MR. DROBOT: So thank you very much for this opportunity. I'm Adam Drobot and I am responsible for applied research at Telcordia. And my folks have been looking at the issues of broadband for a long time, focusing on a couple of key points during the last few years. So what I'd like to do is walk through those points. I'm fairly bad at taking instructions. I was asked to

look at two concepts, probably be more than that, so let me start on that.

I'd say the first notion I'd like to impart is that if I look at the future, and I look at broadband and what that word means to me, it's more than access, it's more than the core, in fact, it's a very complex system that's hierarchical in nature, it has networks at the core that carry great capacity and enable both aggregation of traffic and distribution of it, all the way out to the nodes, which are individual residences. If you map that system out, it has roughly five layers of hierarchy in it.

The first thing I'd like to impart is that to reach a point in the future where broadband actually serves the citizens of the country, has an impact on their lives and an impact on public institutions, there really has to be balance in the way that whole system is built out, okay, and that balance means much more than transport and the carrying of bits, because what I see in the future, if I look to my left, Vint

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Cerf, there's a lot more in that infrastructure, it's computing, it's storage, it's a lot of processing of information that makes stuff useful for our citizens.

So I think having a holistic picture and having the tools to, in fact, examine it before one sets policy I think is fairly important.

I'd say the second point I would like to make is that if you look at that system, there are things that happen on very desperate time scales. If I look at wireless and I look at what is in our hands, something like a handset, you know, what we are seeing is that those are coming out on six to 12 month centers essentially, very fast moving technology. If you start incorporating that kind of technology in health care, in telematics, in other disciplines, how we put together the set of policies, how you build the commercial infrastructures and capitalization of stuff that allows that to be built out in a natural way I think is an important issue.

On the other extreme I would say are the

laws and policies that we have as a nation. They seem to crawl, they don't anticipate what technologies can do, and, in fact, I would say it may be one of the weak links that we have in the chain today, okay.

So if you're moving on exponential time, on internet time, how do you get the rest of the machinery of society to do something that is non-prescriptive in nature, I would say is more behavioral in terms of the approach, that allows us to get to the full exploitation of the technologies that we have.

I would say another key point is really the deployment of broadband, okay, and this is not the glamorous part of building something that runs the terabits, it's really the craft work, the digging of ditches, putting stuff along telephone poles. I see a lot of incremental improvement, but I don't see the fundamental improvement and productivity in that area, and this is one of the things we've been turning our attention to.

And the reason that's important is that

whoever pays the bill to wire up the nation at high broadband speeds, in our estimation, is something that would be well north of $300 billion. To be able to justify that kind of spending, whether it comes out of the public purse or it comes out of the private sector, okay, having a significant increase in productivity I think would make those figures a lot more palatable essentially.

If I were to look at basic conclusions and look at the landscape today, my hope is that we sort of get out of the stalemate that we have today as a nation in being able to move forward in this important area. Thank you.

MR. KNAPP: Thank you, Adam. Vint.

MR. CERF: Well, first of all, Adam, that was spectacular, you finished with eight seconds to spare. This should be a training program for members of Congress. First of all, I'm not using Powerpoint; power corrupts and Powerpoint corrupts absolutely. Second, I think one of the most important takeaways for me anyway

is that it's not just broadband, but it's broadband access to internet that's really important. And I don't mean that to sound egotistical, I only say it because internet, as a technology, allows an extremely flexible way for anything to connect to anything else and for the band widths and capacities of the interactions to be very, very flexibly allocated.

This panel refers to mobile broadband, but I'd like to translate that into, it's probably radio based, because mobile and wires don't work too well. If it's radio based, that doesn't constrain you to mobile only, it also could be fixed, as well as mobile use of radio.

What can we say about today's use of internet? Well, one thing we can see is, there's more demand for two- way symmetry in the capacities that are available. We have the wherewithal to generate video and audio and other things, as well as to receive it, and so that's what you see, you see these devices with video recorders in them and are capable of generating as

much as they receive.

What's nice about packet switching, what's nice about radio is that it can be very flexibly allocated. Packets can flow, they use up a bit of capacity, and then the next packet can go and use up the next piece of capacity, it's not dedicated in any way to any particular application. In the radio world, you have lots of different ways of allocating the spectrum. You can use time division multiplexing, you can use co-division multiplexing, you can use frequency division multiplexing. There are lots of dimensions for sharing of the capacity.

What we haven't done very well in the internet world is to make use of the fact that radio can be broadcast, that is to say, multiple parties can hear the same transmission. Most of what we've done on the internet is to turn the broadcast medium into a point to point medium. I think we've missed some opportunities there and we should be pursuing that.

One thing that you could also see about

the use of mobile communication is geo location. These devices now can know where they are, either because of GPS receivers or because you know something about where the cell towers are and you can do some triangulation. We've seen a change in user behaviors because of that. They're interested in information that relates to where they are, and we see this in the queries that come to Google. So this notion of geographic awareness and the value of geographically indexed information has become enhanced by having mobile access to information sources. Cloud computing, you mentioned the holistic view, all the pieces of this thing, cloud computing is a really big part of the utility of broadband, from my point of view. We exploit that, and others do, as well, at Google.

I think I also want to draw attention to open source notions, because one of the things which has enhanced the value of having access to broadband resources and to internet has been the sharing of software that allows people to develop

new products and services.

Google believes implicitly that by sharing capability, you enable others to make more value of the underlying facilities. So we've released things like android operating system and the chrome browser, and later it'll be the chrome OS, we'll all be open source available. We build API's, application programming interfaces to google earth and google maps as a way of allowing others to generate value from the underlying infrastructure.

If I were to summarize a philosophical position that I would strongly urge, it would be to maximize the utility of the broadband infrastructure investment. And by this, I'd like to argue that it is not necessarily maximizing the revenue generated by a party who builds that infrastructure, but rather to make that infrastructure go to work for a broad range of application providers. If we want to maximize the utility of the broadband investment in the United States, it needs to be very widely accessible to

parties who can bring value to that investment, and that may be many, many more companies than the one that actually builds and operates the underlying component. So I'm a strong believer in trying to create real value and open entrepreneurial opportunity for anyone that can take advantage of that broadband facility. Thank you, Mr. Chairman.

MR. KNAPP: Thank you, Vint. John. Let's make sure that we reset the clock. Okay.

MR. CHAPMAN: Hi, I'm John Chapman, I'm with Cisco Systems and I want to talk a little bit about broadband access in the cable industry. So on my first slide, I take a look at -- I just want to explain how the cable system works today to kind of give you a perspective. We basically have a frequency spectrum of somewhere around 750 megahertz to a gigahertz, and that's divided up into classic TV channels. So for broadband, we basically put data over those TV channels. I wanted to measure the efficiency of the spectrum, so I took a look at the services that are on in

today, which is really analog video, broadcast digital video, switch digital video, and upcoming now is DOCSIS, where we put the date over it, and video in that might be like an mpeg four and the other services are mpeg two.

If we normalize DOCSIS at 100 percent, it turns out analog video is using about two percent efficiency of the spectrum. And so there's a series of legacy -- on cable that, as we migrate from where they are today to future services and future transports, we can actually pick up a lot of efficiency.

I calculated today that the network is probably running at ten percent efficiency, which means just through service migration alone, we can get a 10X improvement in band width. Next slide.

And so kind of to put that together, so if we were to take analog video, migrate it to digital video, and migrate that to switch digital video, and eventually migrate the whole thing to IP video over an IP infrastructure, so we have a converged transport of data, voice, and video, we

would see huge efficiencies, increases in the network, with not a lot of -- without having to rebuild the network. There's a lot of potential in the existing network. Next slide. I mentioned DOCSIS, I just want to touch briefly on what DOCSIS is. It's the technology for building broadband pipes over the cable infrastructure. The cable infrastructure is actually a hybrid fiber coax, it's a partial fiber, partial coax infrastructure.

It's about 13 years old at this point in time. It originally came out at one to two megabits per second of the downstream. A typical installation today has 12 to 24 megabits in the downstream, which is a lot of -- considering that, you know, T1's were one and a half megabits and were seen as the backbone of the internet just a few years ago.

And DOCSIS 3.0, which is coming out right now, will combine four to eight channels together. And already we've seen operators like Cablevision deploying 100 megabits per second in

the downstream.

The technology itself can be scaled in the future. We think that we could probably push DOCSIS one day to take the whole downstream of one to five gigabits, and we think that we could push it to a gigabit in the upstream. Next slide. The question seems to be on everybody's mind is, when are we -- do we need a gigabit cable modem, will we ever get there?

SPEAKER: Yes.

MR. CHAPMAN: Well, if you're old enough to remember a 300 mod modem, you're young enough -- you're going to be young enough to see a gigabit cable modem. That's 300 to a billion bits difference in less than half a lifetime. Next slide.

So the two concepts I think that I want to leave the FCC with, one is that the existing network that the cable guys have has a lot of potential in it. It's not necessary to rip up the existing networks and replace them all with fiber. A pure fiber network is not the only ticket in

town to get to massive broadband deployment.

There's a lot of upgrades that can happen I think on the cable plant, from minor upgrades to major upgrades. That might be things that the government can influence. Certainly, technology is like mpeg four, which is a higher level of video compression. NIP, which is just a much better mechanical mechanism for getting bits to flow, can help a lot towards delivering services.

And I think the other thing I would leave the FCC with is to encourage investment, to set up an environment where, you know, today, when cable operators go to upgrade their network, the immediate response from Wall Street is, that's going to cost money, profits are going to go down, stock prices goes down, and it's a negative environment for investment. In reality, when you put money into your network and you get more services out of it, it's very much of a positive. So I would definitely encourage our customers to keep investing in their networks. I think that's

it. Thanks very much.

MR. CERF: You're ahead of the game here.

MR. CHAPMAN: I guess Powerpoint doesn't ultimately corrupt.

SPEAKER: It keeps you on schedule at least.

MR. KNAPP: Thank you, John. Henning.

MR. SCHULZRINNE: Good morning. My name is Henning Schulzrinne, I'm at Columbia University. Next slide, please. I'd like to highlight what I believe are some of the changes that we will likely see over a time frame that I would estimate somewhere in the decade range, so certainly within the investment horizon or the planning horizon that we should be thinking about.

The first five kind of major architectural -- As Vint already hinted out, we are moving very much from an asymmetric consumed content model to a symmetric model, for a variety of reasons, namely that we will see more upload, backups, user generated services, video, but we

will also see a symmetry, not just in band width, and I think this is an important consideration, but also in network -- We tend to think of kind of a single device, logically, and then gets split by a network address translator into consumer only devices. That has -- network architecture of the internet as it was envisioned originally, making it extremely difficult, cumbersome, and unreliable to provide services that are necessary, where data from censors and other sources is provided from the end user to the network to other users.

ITV6 and the liberal provision of address space to end users will be crucial, not just symmetric band width. We will simultaneously see higher and lower peak to average ratio, higher in the sense that users will expect to burst at very high rates because, for example, they want to download video content very rapidly or upload photos, for example, and lower in a sense that instead of just being a daytime activity, lots of activities will be taking place throughout the day, such as backups, video downloads for

consumption later and so on. We'll see two kinds of new applications. The substitution applications, obviously, was already hinted in a sense that instead of having dedicated infrastructure and channels for video, we will see all IP infrastructures, but also new application that impose not just new band width requirements, but new architectural requirements.

I will just highlight three of them, namely, energy management, home safety, and medical monitoring, as applications that each impose very new requirements in terms of availability, reachability, and reliability.

Also, I believe we have traditionally made a division between having a distinction between residential services, which are seen largely as by the name consumer services and business services. I think that distinction will largely disappear except for the very largest companies.

Anything up to a mid size company with multi gigabit of network will find the same

infrastructure used as opposed to running saying dedicated T1 lines to them. So we have to plan not just for the notion that these are Facebook users, but these are actually going to be small and mid size enterprises who crucially depend on network services liability. In general, I believe beyond band width, we need high reliability for many of the services, medical monitoring being an easy to understand example, and that reliability mainly to be maintained even in the face of power outages. Next slide, please. If you look at new services, we have multi homing, where not just an end user will not just have a single network such as a cable or DSL type network, but also want to combine those networks primarily for backup. That is very hard to do from a technical, as well as from a business model perspective. I don't want to pay for two networks, I want to pay for a backup network in case my primary network goes down.

I want to move content closer to the edge of a network, so we need to think about

vendor neutral and content neutral means of hosting content and computation close to the edge.

I see ISP's and similar services as providing more than just bits. They're uniquely positioned to provide services such as identify services, for example, to certify the identity of a user name, address, and role, as well as certify specific and geo location. We need both services for security, we need them for E commerce, and we need them for reliable next generation 911 services.

I also see a role for preventing -- for using internet service providers to provide much better security to the network at large, because with that type of band width, a single node can do much more damage than a modem connected node, for example, could ever do. So those are some examples of the changes which go beyond just adding more bits per second, go to adding more services, and thinking about the kinds of services that we would need in the future. Thank you.

MR. KNAPP: Thank you, Henning. Paul.

MR. MISENER: Thanks, Julius, very much. And Juli and Walt sought from Amazon a cloud visionary; unfortunately for you, you got the neutrality guy instead, but fortunately, these are related. We recognized about five -- six years ago that our infrastructure within Amazon.com was built for peak, peak selling season, peak times during the day for different time zones and so forth, and as a result, we had a lot of extra capacity for storage and computation and other forms of processing. And so we decided to open up that infrastructure to others to use, and this is the birth of cloud computing at Amazon.

We currently offer a whole suite of cloud computing applications. There's, obviously, storage, there's also a data base and computation facilities that are available for users on a per usage basis, which allows consumers and SME's to obtain computing capacity and facilities that they would not be able to otherwise. If they had to go out and buy a very sophisticated computer with lots of storage just for some limited

applications, it would be uneconomical for them; rather, they can come and buy ala carte from Amazon and other providers such as Google and Microsoft.

These kinds of services obviously rely on consumer's ability to get at them. And so a very important philosophical point, which is translated into a regulatory position over the years, is, Amazon has long favored the fundamental openness of the internet, which is good for consumers, it's good for the entrepreneurs who serve those consumers.

It's also -- importantly, this is something, a policy matter squarely before the FCC, this is dealing with the openness of the infrastructure that is available to consumers and small businesses. And I completely agree with the point that those will become, and already largely are becoming indistinguishable.

Companies like Amazon are able to obtain the telecommunication services that they need in a negotiated environment. There's not a concern on

that side of the web. We are in more or less equal bargaining position with network operators and we're able to obtain those services in a collaborative fashion. Consumers and small businesses aren't in the same position. They often face one or two service providers and set prices. And so this is clearly an area where government oversight and intervention is appropriate.

So what is the status of neutrality? Well, I think we're in a position of détente, and it's actually an unhelpful detente in the sense that I think both consumers and network operators would benefit if the détente were broken. I think Adam said earlier it's a stalemate. I think he was talking about technology, but there also is this fundamental regulatory stalemate in which we find network operators are unsure of what they may and may not do without receiving unfavorable attention from regulators, and consumers may not be benefiting from new services that would otherwise be available to them.

So we were concerned five and six years ago, not we, but the network operators primarily, of the unintended consequences of regulation. Well, at this point, I think we're seeing almost the flip side, the unintended consequences of no regulation, where we're not able to get the clarity for the service providers, nor the new services for consumers. And so just as a -- sort of a softball almost or a straw man for what sorts of services I think could fall under sort of lawful or regulatorily permitted kinds of services offered by network providers, certainly metering.

There's been some almost allergy to the thought of charging consumers who use more band width more money. Well, I think that's entirely appropriate. That certainly happens for companies like ours. We certainly are charged a lot more money than smaller internet services providers or edge providers like Amazon.

That kind of metering of consumers, the 24/7 gamer, makes perfect sense. It's economically efficient and it would certainly

reward the network operators who could provide that kind of capacity.

Obviously, private networks have always been with us, they're certainly appropriate. Those have always, or typically been in the circuit switch mode. But a private network in the pack of switch mode seems to be perfectly reasonable, as well as edge serving by network operators, who -- they ought to be able to be in that same sort of a business. One of the questions that always comes up is, paid QOS, whether that ought to be appropriate, and it's always seemed to me that that would be appropriate so long as other customers of the network operator are not effected. So as long as it's not a zero sum game, sure, provide it, it's more or less like another private network that just happens to reside in the core rather than around the edge. I'll get it down exactly to zero. Thank you.

MR. KNAPP: When I looked, it said one, plus one. Thanks. Those presentations were fantastic, thank you all. One of the points that

we had touched on, we, I think in the past, have thought about broadband in terms of the internet. And as we're thinking about new applications going forward, there's so much more that's coming, the smart grid, health care applications, we talked about safety and security and so forth. How should we be thinking about what broadband is, how do you define it, aside from I mean the classical, how many bits per second? And maybe, Adam, do you want to take a shot at that first?

MR. DROBOT: Sure; let me try actually from two different perspectives essentially, okay. You know, when I look at a consumer or a business, they really don't care one damn whether it's, you know, what the speed is, it's what it does for them. So tongue and cheek, if I look at the language that we use, we have, you know, a 2G, 3G, 4G world, and I'd say that there is a 5G and a 6G world behind that, so let me try and define what those are. So the first of those, which I would say is 5G, is the ability, in fact, to give me the material that I want when I want it, and I'll

define that access as -- So on top of ability and speed of stuff, how quickly can you deliver something to me when I need it so it's relevant.

That doesn't happen without having a computing plant and a lot of other infrastructure that's in the system, okay. Whether it's provided by outfits like Google, Amazon, they're the services that are already in that 5G world, okay.

Then I'd say beyond that is really the world of anticipation, okay, much more computing intensive, much more personalized essentially, and this is where I see applications such as health care, you know. Why do I want to monitor someone? So I can know how to do something ahead of time, okay. Running out of gas on a highway, okay. If you look at what your secretary does for you, it's really anticipate what your needs are going to be downstream, how to schedule your time, how to find opportunities for you, okay. And the point I'd like to make is that when you look at the life cycle, okay, of putting a broadband system together, there will be a lot more that probably

goes into this part of the infrastructure than goes into just providing the pipes essentially, okay. So that's one way of framing it, I would say.

MR. KNAPP: Hang on a sec. Yeah, Henning.

MR. SCHULZRINNE: Vint I think was first.

MR. KNAPP: Oh, I'm sorry.

MR. CERF: Don't worry about it, go ahead.

MR. SCHULZRINNE: I think we should think of a network as a fundamental utility infrastructure, that is, compliments the infrastructures that we're used to, energy transportation and so on. And we think of those infrastructures, if you're not a civil engineer, as working best when you don't have to think about it.

We have to think far too much about the network today as a normal consumer. When I talk to my non- networking friends, and they tell me

that they had to use ping and a trace route, I say what have we -- we should not -- this is not an infrastructure which is ready -- a normal consumer does not need to know the difference between an amp and a volt, and most probably don't. We now have to create an infrastructure essentially invisible to new applications, because by the very nature, applications will change much faster, and the network should not be in the way of those applications. All too often, as I hinted out earlier, in the past few years, new applications, voice and video being one example, have become much more difficult to deploy, become much more brittle, and have much poorer performance because a network was not invisible and very much interjected itself by port filtering, by having restricted address space, by having asymmetric band width -- of address -- of services. So we know what happens when we don't have invisible network, we get delayed and inferior services.

MR. CERF: So I certainly resonate with what Henning is saying in this regard. I think of

broadband as an enabler more than anything else, and treating it almost like a utility. I don't mean to drag in necessarily all of the baggage associated with the term "utility", but the idea that it is utilized by a broad range of consumers is important.

For example, in the case of electricity, we don't dictate what appliances you plug into the system. The internet, in theory, need not dictate what applications you run or what devices are connected to it. It's openness and freedom of invention is exactly what has created so many new opportunities. And it seems to me that as we try to fashion policies with regard to broadband deployment, we should keep in mind that this unbound notion of access to high capacity is what enables all kinds of new opportunity.

One thing I would remind everyone is that high speed provides you with two different important values; one of them is the ability to move a large quantify of information quickly, which gets to Adam's point about how quickly do I

get a response when I'm trying to get something done.

The other thing is that latency, for certain kinds of applications, goes down as the speed of the transmission pipe goes up. And you don't necessarily need to use a large quantify of something to benefit from low latency. So when you're dealing with twitch games, kids are shooting at each other, or you're trying to have a video conference or something, the latency part is really important.

So the benefits of being able to get access to broadband then use it in different ways is what's essential here. And I would be unhappy I think if our regulatory policies or our implementations and deployments constrain the flexibility with which we can actually use the broadband resource.

MR. KNAPP: John.

MR. CHAPMAN: I would just add to what my colleagues have said, you know, in networking, we have a layered model, and I think it would be

good to take a look at the definition of broadband with respect to that layered model. So broadband isn't an all encompassing term that takes in everything. Really at the lower layers we have, you know, what Henning was talking about, port filtering and stuff, it's really the operations of IP, it's the mechanics that make a link work. They are strictly mechanics.

It has the internet protocol, or maybe it's an ATM protocol or something like that, but that's what makes the pipe work, and that's what people run into. Broadband is actually I think a service that links you from your home into the internet. And the internet is a collection of a whole source of applications that you're going to be talking to. So if it's a health care application or if it's a Google search or something like that, those are applications on an internet. Broadband is the connectivity between those two points. And I mean I think it's important really to keep the layering and focus on the one part of the layer that you really wanted

to find.

MR. KNAPP: John, one of the things that you had pointed out, and we still have a lot of the capacity on the cable pipe that's delivering analog TV, which there are requirements that have to be maintained for a few years, and eventually that's going to be recaptured. Where do you see that going, devoted more towards the broadband side, I mean internet access, or are we going to get another 25 TV programs?

MR. CHAPMAN: You know, I think analog reclamation is one of the biggest bang for the bucks. Every analog channel you get rid of, you can replace it with ten video channels on digital, and once you go over to IP, it can be 20 or 30, and I think where we really end up seeing the growth, there's only so many TV channels you can put out there.

I think that the actual content -- I mean here's another interesting way of answering the question, because I have Vint to my right. I would say the cable guys are the Googles of the

'70's. They're the old guys from 20 or 30 or 40 years. They were content aggregators back in the '70's, who aggregated content from antennas. Now we have guys at Google aggregating content from everybody's living into the network and generating some really good, new content. But back in the '70's is all about, instead of two or three TV channels, how can we aggregate these together. So they aggregated content together, and there was no network at the time, so they had to build a network really as the byproduct to get this all out.

So where are they going today? I think they have to migrate towards the new content. There is only so many TV channels out there. As we get more efficient at packing those TV channels in there, it will open up more room.

I think that we're going to be see gigabit pipes on their network within the next five years, and I think that there's a lot of business to be had in pulling in content from the internet and delivering it to the user. So, yeah,

I mean I think it's really all about migration of legacy services towards newer transports, and I think IP TV is one of those newer transports, and --

MR. CERF: Thank you. Well, first of all, I think there's only a finite amount of quality in the universe, and I can prove it to you, because if you look at the quality of any typical television program today, when you have 500 channels or 1,000, it's pretty clear that each one of them has about.01 percent of the quality of the thing we had 30 years ago. So there's -- and that -- I mean it speaks, in some sense, exactly to your point, which is that there's only a finite amount of content produced in that fashion that is going to be of interest to people, and that's an important fact economically, because if people are not very interested, then it's going to be hard to use advertising as a generation -- revenue generator to pay for the cost of all this stuff.

So as the notion of these media, television and music and everything else, migrate

towards the IP transport, people's behavior patterns I think are going to change, too.

A lot of people don't pay any attention to when something is transmitted over the air or through the cable at all. They're not interested in the timing, they're not interested in being aligned with 8:00 on Wednesday, they're more interested in watching whatever that content is whenever they want to, and so as a consequence, they download it and play it back. Downloading is a very interesting proposition, because if you're not watching while it's being downloaded, you don't care whether it's delivered exactly at the right times, and you don't care if a packet gets lost because you can retransmit it, or there's one that's delayed and the video would break up, nobody cares because it's just a file transfer. The consequence of that is a great reduction in pressure on the packet switch net to deliver things exactly on time and everything else.

It doesn't mean that there isn't going to be any real time, there absolutely will be.

Video conferencing is an example of that, emergency broadcast, news and things of that sort, sports events are all things that people care about when they happen, but 85 percent of all the videos that people watch is actually pre-recorded stuff.

The consequence of that is that a huge chunk of the transport capability of cable and fiber and everything else could be allocated to this much more flexible way of using the band width to obtain entertainment, whether it's music or video or anything else, or purpose it for other applications when you're not using it to download or watch streaming video.

So I'm a big fan of what you're doing, John, in terms of opening up the capacity to provide broadband flexibly allocable capacity that people can purpose for whatever reason they have in mind.

MR. KNAPP: I've got a long list of questions. This material is so good. But I'm going to give my colleagues a chance to ask them

because I know they've got at least as long a list. Stagg, go ahead.

MR. NEWMANN: Okay. Let me preface this; when Paul and I were at the Commission, there was sort of a motto of do no harm, and two things we did, you can argue whether that was right or wrong, there was pressures from the Hill to take the internet and the common carrier title two regulation primarily so it could be taxed to subsidize telephone service, exactly the opposite of what a corporation would do, right, you take the old and fund the new, we were being pressured, and we chose not to do that, we chose to regard internet, not as a telecommunications service.

There was strong pressure from AOL, which was a narrow band dial-up company at the time, and the traditional telephone industry to apply open access obligations on the cable industry because the business case for DSL was negative and AOL had no broadband strategy, and we chose not to do that, we chose to allow the cable industry to invest to scare the Telco industry to

spur investment, okay. You can argue whether that's right or wrong, but that's sort of the short form of the history. Now I'm hearing from all of you, we're moving to a much more complex networking area, from cognitive radios, et cetera, storage and computing being a critical part of how we think about the infrastructure.

Where as policy-makers do we need to focus our thinking and where should we say, do no harm, let the marketplace take care of it, to foster this next round of technology development?

MR. CHAPMAN: I'd say it would be helping the various service providers move to the next paradigm, as opposed to mandating -- I mean competition will get them there. We see like Verizon and the cable companies are having a field day at who can make the fastest link, and that's a market driven force, which is very -- which is working really well for consumers right now.

And I think allowing, for example, the Verizon guys to get into the content aggregation, which they've done on their own, and allowing the

cable guys to be able to migrate away from legacy services and get -- upgrade their networks and build faster networks, I think all that is -- it's really helping clear out the old so that people can build the new.

MR. MISENER: Well, Stagg, thanks very much for that. I think the consumers are legitimately concerned about the ongoing openness of the internet. And there have been widely publicized incidents where that openness has been closed temporarily and intentionally, and as a result, there is this détente, about which I spoke earlier, wherein network operators don't know exactly what they may do, or even have sort of general parameters in which they may operate, and consumers are continuing to be concerned about it and maybe aren't seeing the new services the net ops could offer, if only we had a rational discussion about it.

So I really would hope that the policy-makers would focus their attention where the market is working least well. It's not a

total market failure, it's not a monopoly anymore in most places as a duopoly, and there is some level of competition. Would I call it perfect competition? Of course not, and I'm not sure anyone would.

But at the same time, I don't think it's fair to impose, you know, the sort of Damocles over network operators forever more, where they have no idea whether they're going to get slapped for one particular new service or not. I think it would be helpful to them if consumer groups and edge service providers, as well as network operators, came together and could break this détente with rational rules --

MR. KNAPP: Henning, go ahead.

MR. SCHULZRINNE: Okay. I think the core aspect which I see is currently missing is the lack of transparency, particularly for the consumer side. For a normal consumer to have no cost transparency, no performance transparency, and no predictability, we have no cost transparency in a sense it's often hard to predict

how much it's going to cost them to actually run the service because of fees and various other things.

Switching costs to high, so once I commit to a particular service, I cannot, like going say from being to -- or vice versa, it's the switching cost are high and will become higher because infrastructure in the home will start to depend on whether I choose cable or not. And I'm not going to tear up my wall because I decided the cable company didn't quite deliver what they promised.

Transparency performance, I have no way of finding out, as a normal consumer, whether cable or fiber or wireless is more reliable and what the real performance is. Up to ten megabits per second tells me very little as a normal consumer. And all other long term purchases of that nature I can predict hopefully as to what my performance is, because consumer report tells me for -- what my maintenance costs are going to be, no such reasonable way to do that.

The final is transparency in the sense of, we tend to protect the encumbrance, both in terms of applications and in terms of infrastructure. What we don't see are the ones that never make it, simply because they're not at the table when decisions are made. And I think the fundamental value of a network is things we don't know yet.

We couldn't have protected social networks and video when we wrote legislation 20 -- 15 years ago because they didn't exist as viable businesses, they were, at best, garage businesses.

So that's why I think network transparency that allows everybody access to the same network services where technically feasible provides exactly the type of predictability. As long as they offer the same service to others that are offered to my own customers, I can offer the service, that's a rule that I can understand as a technologist, and having a finite and small number of interfaces which are long term. We've had those number of interfaces, this is basically IP

and the optimal layer primarily that have been stable on time units which legislators and regulators can deal with. They haven't changed, whether it's IP -- it doesn't really matter, for three decades, roughly speaking at this moment. So focusing on those interfaces, those are the cut points that are high value, high return interfaces to look at.

MR. KNAPP: Can I ask the other panelists' reaction; do you agree or see it differently? Yeah, go ahead.

MR. DROBOT: I have I'd say two things, having heard this. You know, the first is that, as much as we know today, we probably don't know more about what the future will be. This is an era of experimentation, a lot of stuff is happening, and I'd say the first place to do no harm is not to stop that experimentation.

At the same time, okay, I think we see a struggle, and that is that the infrastructure in which that experimentation, okay, has to be paid for somehow. Whether it is paid for out of the

public purse or it is done through the private sector, leaving too much ambiguity prevents the set of rules under which investments will actually happen. Those have to be predictable. And we are sort of living in an era right now where the rules aren't there. And I would say what that does is prevention of capital, encouragement of a lot of things that really underlie a very complex system, okay, and so when one part of it falls behind, the rest of it sort of stumbles essentially.

MR. KNAPP: Vint.

MR. CERF: So a couple of things; first of all, I can -- I believe that the sense of competition is viewed differently depending on which eyeball is looking at it. If you're a consumer and you ask yourself, how much choice do I have in broadband provision, the answer is often, not very much, sometimes it's zero because it isn't available at all.

That may happen a lot in the rural parts of our country, or it might be one provider, it could be a Teleco with fiber, or a DSL or it could

be a cable carrier, or it might be two, it might be a cable company and Teleco both offer you broadband access to internet. But it's not very uniform, and there aren't a large number of facility based providers, and there probably won't be. I mean the economics of facilities based provision may not allow for five, six, seven, eight, nine, ten different competitors. So that suggests that whatever policies we adopt with regard to broadband have to take that kind of thing into account, that where there isn't very much competition, we need to be conscience of the need to keep the provision of services open as possible.

And I accept that as a cable company or as a telephone company, you feel competition where there is competition, so not for a moment do I argue that there is none, it's just that it isn't uniformly spread from the view point of the consumer trying to choose what services are available.

And I agree with Henning, that switching

costs are very high now compared to what they used to be. When it was dial-up internet, you just dialed a different number, that was easy; today, it's a truck roll, and it's a lot more complicated, so that's one thing.

The other thing, with regard to the detente question, in a conversation recently, a very interesting thought was put on the table. I was ranting about non- discriminatory access to the internet and my deep concern that the people providing the underlying broadband facility would somehow constrain competition at the higher levels. And so while I was having my rant, it was pointed out to me that I was at one end of a spectrum, and that the spectrum included the notion of differentiable services, which might not be anti-competitive, they might simply enable certain kinds of services that wouldn't work if you didn't have some differential quality to access to the broadband.

And then as you run along that spectrum, you get to the point where the differentiable

services become anti- competitive. So now the question is, how do I figure out where, you know, a particular proposition lies on that spectrum. And I don't for a moment suggest that this should be a problem that our legislators try to solve. This is the kind of problem that you almost have to deal with on a case by case base.

But recognizing that there is a spectrum, and recognizing that there's value at one end and there's potential hazard at the other, suggests to me that mechanisms and procedures should be looked at to maintain this openness, but also recognize that there a the possibility of doing something different in the net to support different kinds of services that are not necessarily anti-competitive.

MR. KNAPP: Bill, we know that you're still out there, I just want to let you know we hadn't forgotten you. If at any point you want to jump in, just give a holler. We had a question from the floor that I think is a good tie into what we were just talking about, and I'll

paraphrase a little bit, that a lot of the discussion seems to be centered around there's an infinite capacity or band width available, but the reality is, it costs money, particularly in the rural areas. So how should traffic be prioritized or band width rationed or some tiered pricing levels for certain services and so forth, recognizing that if everything is open, and we can't predict the applications, how concerned should folks be about the traffic jams and how that gets managed? I thought that might get some reaction. Go ahead, Vint.

MR. CERF: An immediate reaction to that; one of the problems that I see happening is a concern for how much does any one user actually consume. And it's possible for some users to consume more than they are paying for. So what do we do about that?

The first observation is that you want to constrain users to -- I want to say this very carefully, it is the band width, it's the bits per second that are the problem. It's not the volume

of traffic that you move, it's the speed with which you move it. If I move a terabyte of traffic over a two month period, no one will notice. If I move a terabyte of traffic over the next ten milliseconds, everybody will notice, because I'm taking all of the capacity of the system. So if you're worried about consumption or over consumption, your problem is how to limit the band width that any one user is consuming.

There have been some very let me say clumsy attempts to cope with that problem by putting volume limits on what users can send in the course of a month, for example, and I don't think that gets to the key problem, it really is what's the band width that the user is consuming.

MR. KNAPP: And to follow on with Victor, and Henning, and Bill. You also talked about research, and not only be interested in what research that's being done and where the holes are, but how it ties into -- are you looking at these kinds of things down the road, and I think Victor has ---

DR. FROST: Well, I just wanted to make a point about the constraints and things. A lot of this goes back to the business model you're working with, who pays for it, and right now, revenue is generated off the internet by advertising, and not necessarily the end consumer is paying the full load of all the servers and the technology that is in the network. So maybe different business models, where, if I wanted to get more band width or wanted to get a certain download, the advertiser may pay for it, not the end consumer. And so it may be a model of how different business models could evolve to support ---

MR. CERF: You surely don't mean that advertising is the sole means of revenue generation in the internet because people pay for access to the internet, they pay money for that, and it has nothing to do with advertising. I pay, you know, I don't know, $100 a month for my access to the internet.

DR. FROST: That's right.

MR. CERF: So I mean that's another revenue source. And in the business world, people pay a lot of money, including Google, to get access to the internet to provide services, so you surely didn't mean that that was the sole ---

DR. FROST: No, that's not the only ---

MR. CERF: Okay.

DR. FROST: But there is another means.

MR. CERF: Okay, sorry.

MR. KNAPP: Victor, if you can just follow on the research side that you talked about before. What is it that's being -- where are the holes in the research?

MR. CERF: Oh, there's some big ones. I mean the point that I tried to make earlier about, you know, the ability to share radio land with in a more flexible way, that's one big hole, because we just don't do it very well. The second big hole is that security in this internet architecture sucks, that's a technical term.

And, you know, we treat the symptom right now. We tried to deal with botnets that

generate spam and that generate denial of service attacks. When we try to defend against the DOS and we try to deal with -- by filtering the spam, we're treating the symptom, we're not treating the cause. The cause is that computers are vulnerable, they are easily penetrated.

MR. DROBOT: Operating systems.

MR. CERF: Yeah, exactly. And so it's not just the operating systems. The biggest hole in the computers today, especially PC's and iPods, is the browser. What does it do? Think about it folks. What does the browser do? It goes out into the internet and it pulls a file from some destination site and then it interprets it. The copyright guys go nuts because the internet is a big copying engine, that's how it works, at least the world wide web part. So the biggest hole we have is that the computing assets of the internet are vulnerable to being overtaken by the bad guys. The only way we're going to fix this problem is to build much, much more secure computers. And that's not a trivial task, it's going to mean

combinations of hardware and software, it's going to mean cyber hygiene, as in, you know, you brush your teeth once a day as opposed to once a year, because if you do it once a year, it doesn't do any good, that means you have to have some serious ability to detect that your machine is infected, you have to have ways of disinfecting it, you have to have ways of defending against the various kinds of worms and other bad things, bad mail ware that show up. That's a space where serious research is needed.

MR. KNAPP: Bill, is this a chance for you to chime in and share some of your thoughts on this?

MR. ST. ARNAUD: I just want to echo the comments made by the panel. I think there's two types of experimentation we need to do; one is -- technology in addressing these issues of security and so forth. I think it's also important that we do experimentation on the business models. We've got to find a way of funding this deployment, and I think, as I mentioned before, some of the ideas

coming out of Google on the Homes With Tails is an example of this type of thinking that we need to look at how we fund the deployment of broadband.

MR. DROBOT: So Julius ---

MR. KNAPP: Yes.

MR. DROBOT: -- let me do the following thing. If you look at pipes that are severely constrained, and you expect that the same level of service is going to happen over those as over bigger pipes, the fact of life is, no matter what you do with QOS, it ain't going to happen.

MR. CERF: Any time you substitute ---

MR. DROBOT: There is no substitute for real band width. And I think you have to turn to -- it's not a technology proposition or a research one, it's really the following; if you have societal goals and aspirations, what you'll find is that commercial outfits will do what is good for them, okay. If you want to have this universally available, you have to pay the bill for it, and I don't know of any substitute for that.

MR. KNAPP: Henning, go ahead.

MR. SCHULZRINNE: All right. Because I want to kind of emphasize a point that I think Vint was starting to allude at, is, we tend to think of band width as something kind of a constant. We really need to add two components to band width, namely time and location. Vint already hinted that many of the high band width application are time deferrable. So -- and I noted very briefly in my introductory remark that we have unfortunately a flattening curve of band width usage in residential market, and I looked at that for Columbia University over a day, so that's not as big an opportunity as it used to be, but it's still a factor two or so in terms of utilization at least, even for a large entity like Columbia.

So we have research opportunities to essentially make it easier for application to defer usage. In the electrical grid, in the smart grid effort, which I'm peripherally involved in, we call that demand reduction and demand

management. Opportunities to do that and the research opportunities that go along with that are -- and that goes in the second one, is also location.

If you look at the band width cost in many networks, it is not the last mile, because that has been paid for. If you have -- and this is a little different for the HFC architecture, but if you look at fiber to the home, and if you look at DSL, the DSL cable isn't going to consume anymore cost by using it 24/7, it's the internet access paid by the DSL provider that does that. So making band width usage more local, making -- pulling the band width in so that you don't end up downloading the same movie, that same channel 50 times to every provider, to do that in a way which is neutral, so that you do not -- right now, only the content aggregators can do that. They have the facilities to do that. ACAMI and similar companies can do it in a limited way, but I can't do that as a new provider.

From a research perspective and from a

policy perspective, the ability to offer such services close to the edge, hosted very close to the last dedicated mile that you have, provides tremendous opportunities to reduce the cost of wide area band width access which is the biggest shoe for wireless, it is the biggest shoe for some of the rural providers, because that's where the difficulties of rolling things -- and if we can help with doing that, we'll reduce all our cost of the network, we provide new opportunities for content, and we allow people, other than the traditional content aggregators, to provide content on an equal footing.

DR. FROST: One of the things I think, to bring some of the points together is, Henning was talking about transparency, and a way you can do that is network management type of issues. If you want to get information about what happened and what's happening in performance back. You mentioned security, you mentioned moving the information closer to the user, all of these are fundamental architectural issues.

And in terms of research, one of the bigger programs at NSF is, or I don't know bigger, but it's a program in my group, in my directorate is, the future internet design initiative that's going on, to try to look back and say how do all these things -- how should we look at these things, maybe from a clean slate perspective or a different perspective, so we get the attributes that everybody is talking about in a common architecture.

And this goes back to the concept of virtualization that may be an opportunity for how a new architecture could evolve, that if you have a virtualizable network, then these attributes that would have economic benefit, but maybe disruptive to the current internet deployment, could start seeing deployment in one of these virtual networks.

MR. CERF: I've been involved the fund program and in the GENIE program and so on. Dave Clark at MIT has been a long term participant in the evolution of the internet, and he wrote a very

-- together with some colleagues, a very famous paper about the tussle. Tussles have to do with people who have different objectives, and they're in the same arena, and they're struggling with each other.

There are lots of tussles that are technical, but there are also tussles that are economic and that are political and that are policy. The reason I bring this up is that it's really important in the context of research to keep in mind that whatever it is that you're doing is going to ultimately be projected into a tussle space, which is not purely technical.

I really like the idea of saying what would happen if we started with a clean slate, not that I believe that we will have a clean slate, but the question is, if you did have one, what did you learn from the last 30 years of this network use, what have you learned from its projection into our business community, our social fabric and everything else, and what does that do to inform the architecture and design of a new more secure

and more flexible system? So I'm really glad that NSF is doing that.

MR. KNAPP: I'd just like to let the audience know, if they have questions, we've got Rashmi Doshi here with index cards, and he'd be happy to take your questions. And I know Rob has a question, and give him an opportunity to ask, too.

MR. CURTIS: Yeah, thanks, Julius. It'll take me a minute to set up, but it's about the intersection between the value stream and the application part of the value stream and the infrastructure part of the value stream.

If you look at and believe, and I'll synthesize, a lot of the Wall Street research today, right, you might conclude that there's kind of a capital crisis, and a lot of the Telecom providers, and it's probably accentuated in rural areas, and I think they would say it might be caused by two or more things, one is over supply of infrastructure in some places, coupled with the inability to extract value from the bits and the

infrastructure in a sufficient way to get a decent return on capital, which, you know, causes a depression return on invested capital, causes a depression in cash flow to build out infrastructure in other places. And I think that the thesis they would have is, there's a, you know, perhaps an imbalance in the way you extract value from the bits. A lot of the extraction is going on in the application layer, less is going on in the infrastructure layer, and that's eventually going to clog our ability to build out the infrastructure and get the band width everywhere that we want.

So the question is, and let's just start general reaction to that, and we can argue, or they can argue, I don't want to get into that, but the argument, is it a factual debate about, you know, whether there is a capital constraint and how the value stream works, or is there another theoretical, more abstract, you know, point that we're -- that they're missing?

MR. CERF: So I have an immediate

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reaction to this, which may not be well thought out because it's so immediate, but my first belief is that the investment in the infrastructure, which absolutely costs money, no debate there, we now want to extract the maximum value from that investment.

Now, it depends a lot on what circle you draw around the value sources that are extracting value from that investment. I don't want to overuse analogies here, but if we think about roads, maybe think about the postal service, think about some of the other utilities, the value that's extracted is extracted by more parties than the one providing the basic infrastructure, and that turns out to be a good thing. Why is it a good thing? Well, it tends to increase the total economy, it tends to increase the amount of taxes that people end up paying, it increases the government's ability to perform its function, and it improves things for everybody, not just the provider of that infrastructure.

So I think -- I'm not an economist, and

I don't know that anything I've said makes any sense from the usual economic lens, but I believe implicitly that the ability for the maximum set of parties to extract value from that infrastructure is what we should be going for. And if that means thinking of new business models and new structures through which to create that infrastructure, then we should be pursuing that.

DR. FROST: I just think that the thing to keep in mind is, the infrastructure --- the roads are like the pipes, but the view of the infrastructure is the servers, is the cloud computing, is everything else from the outside that you see, so it's not just, you know, building the better pipes isn't all that we need to do, we need to have this overall system.

MR. CERF: But you don't want one party, you don't want to rely on one party to do all the invention of the ways of using those roads.

DR. FROST: Oh, I agree, yeah, absolutely.

MR. CERF: So I mean that's why, you

know, to just sort of tout Google a little bit, we really do try to open things up so that other people can get value out of our investment, too.

MR. KNAPP: Go ahead, Adam, and then Henning.

DR. FROST: Let me take one crack at it and sort of break the question into two parts. You know, the first one is, if you look at overall societal benefits for the economy, all of that, I think if you look at sort of the ICT world in general, you know, the economic studies have shown that somewhere between 35 to 40 percent of all growth and productivity has come from the ICT sector, okay.

MR. CERF: Wow, over what period of time?

DR. FROST: Over the last two decades.

MR. CERF: Thank you.

DR. FROST: And it's incredible; I mean if you look at it, it's had incredible impact. If I look at the investment in broadband, and again, I look at this broadly, with mobility at the heart

of it, okay, my feeling is that the next wave of productivity comes out of this, okay, and probably more profound and larger than the last round essentially, okay. So what you find is that there is a lot of incentive for us as a nation, for competitiveness, to really go and make those investments.

At the same time, if you look at the individual providers who are responsible for those networks, I think there are two kinds of problems that they suffer at this point. You know, the first one is, you know, this Wall Street view, if I invest in you, are you going to have the rates of returns, and you know, the fact of life is, in the rural areas where the cost of build-out is high, okay, the answer is, you will not get your return, okay.

And I heard I think from my friend at Verizon, Dick Lynch, okay, what he said is, look, Verizon will do what is good for Verizon, okay, we will build out where we have customers, where it's economical, beyond that, okay, it has to be

subsidized in some way.

So as a matter of policy, I think that is an important area to examine. One more dimension to it, though, okay, and that is coming back to this complex system with balance, okay, what you are finding is that the rate of growth in traffic, while we can do research and try to reduce it in a lot of ways, okay, the technology curves are not keeping up with that rise in traffic, which means that somewhere in our supply chain, the investment in the research and the precursors that lowers the cost of technology over time was not made.

MR. CURTIS: Let me push on that a little bit, and maybe, just for the sake of being provocative. If you believe that building out rural infrastructure creates value, that must mean that you believe there are enough parts in the value chain that capture sufficient value to cover the cost, all right. So that means in some, you know, ideal economic sense, there's plenty of value to pay for the infrastructure. Now all

you're doing is talking about the distribution of value, where it goes ---

MR. MISENER: Correct.

MR. CURTIS: -- correct? So I guess really that's kind of the question, because if you look broadly at the, you know, the Telecom kind of crisis and a lot of the thinking on that, what you see is a belief that we're spending a tremendous amount of money, capital, building infrastructure, and a lot of that value of the infrastructure is getting captured in other places. And if you apply that out to the rural areas, what that really means is, you're going to need to subsidize, you're asking fundamentally, government subsidize infrastructure in rural areas because of the way the value chain is getting caught up. It's not that there's not enough value, it's the people that, you know, and again, Wall Street review, not mine, the people that are building infrastructure just aren't capturing enough of the total value to make the infrastructure investment in rural areas. And I guess that's the fine

pointed question I wanted to get reactions.

MR. DROBOT: Well, no, but I mean the point is to take a run of 50 miles or 100 miles cost more than a run of, you know, one mile.

MR. CURTIS: Absolutely.

MR. DROBOT: Okay. And unless you put exorbitant rates for the person on the other end of the pipe, okay, there is no return, that has to be subsidized.

DR. FROST: But is the point you're making that it's not just the person putting the wire in ---

MR. CURTIS: This is exactly the point. It's a much broader -- we've talked -- the entire session has been about a much broader value eco system, right, and the only -- if you believe that that total value eco system is enough for somebody, let's say the government, to subsidize, right, because you're creating societal value, right, then theoretically there's enough value in the system to pay for the 100 mile run, it's just a question of how you cut it out.

MR. DROBOT: Yeah; how you cut it out, whether you do some distribution as you do through the Universal Service Fund or mechanisms of that sort, or create other economic incentives, okay, something like that has to be done to make this happen.

MR. CURTIS: Got it.

MR. SCHULZRINNE: One of the points that I think this has been alluded to, but I wanted to emphasize it because it plays to this particular discussion is, the expectations for return are quite different from different parties. These days, I'm lucky if I get one and a half percent on my CD. And I don't expect, as an individual consumer, ten percent returns on my investment.

I have, however, no opportunity at this point and this place to the House of Tails and all of these type of things, I have an opportunity realistically to make a long term investment to buy my own fiber in a community, and I would be -- I buy my own PC, I don't -- we are in the broadband world, lodging the world of renting

phones like we were for AT&T. They're selling us an instrument and a service. We got much better phones once we were able to, with a long term commitment where I didn't have to, unlike say in the set top box model, where I would be foolish to buy my own set up box because the likelihood is two years from now, that set up box will no longer work or no longer have a functionality.

If we have guarantees of stable interfaces at core layers, and we have some historical background, we know we can do that, Ethernet IP being examples of that, or upgradeable interfaces in net, I think there's ways to capture the consumer value that is not available right now, simply treating it as not as -- I don't expect, not anymore at least, most people, a ten percent return on my home, I get it because I want to live there.

And we should treat broadband in many ways as a nicer set of carpets a nicer set of a swimming pool, and I'm willing to invest in that. And if we can capture some of that value, that

makes the calculation not completely different, but it provides an additional uncaptured fund, we have no means of doing that right now.

MR. CURTIS: That's an interesting way to think about it.

DR. FROST: I don't want to advocate this as a -- but the value -- who gets value from it? What is the value to Amazon to be able to get to 10,000 people in rural Kansas? That's 10,000 more potential customers to them. Now, should they be contributing to building that infrastructure out to those 10,000 customers?

MR. DROBOT: Wait a minute ---

MR. CERF: They are, they pay their ISP.

MR. DROBOT: -- they already pay -- they already pay to get access to the internet for the purposes of delivering this stuff, right?

DR. FROST: Well -- but he's getting to the value chain. I mean I'm not advocating that, but I'm saying there's value -- is the total value then being ---

MR. CERF: I want to take Henning's

point for just a second and make an observation. People -- we're not enabling people to make long term investments in something that will be useful over the long term. If you buy a PC, it's not clear how useful an investment that is if it runs out of gas, right, that's why cloud computing is such an interesting proposition. But right now, there isn't even any opportunity for me to invest in paying for a piece of fiber that, you know, I can make use of over a long period of time or allowing communities to cooperatively make that investment. I've seen attempts to prevent people from building their municipal networks and so on, and I've always scratched my head about that thinking, wait a minute, there is one example of an economic -- an attempt to make an investment as a thoughtful community in order to have a long term asset. So Henning has got a point there, and I don't know why you wanted to get Amazon to pay for it. Well, if Amazon wanted to pay for all of it, it would be okay with me.

MR. KNAPP: Just say yes or no, Paul.

MR. MISENER: Well, let me take a shot at this, too. It's not a binary proposition, right. This is not should we do it all or should we do none. It seems to me that there are diminishing returns. For the consumer who happens to live in the middle of a 400 square mile ranch, does it make sense to subsidize a broadband connection for him or her? Well, the answer is no.

But a reasonable national broadband policy seems to make a lot of sense. Policy-makers like Senator Dorgan for years have been pushing for this sort of thing, and it probably does include subsidies. You think about it, you go to a hotel room, there's a TV and a telephone, I never use either, and yet I have to pay for my internet access. It's the kind of thing where we are already, as a government, subsidizing a lot of programs that are arguably a lot less worthy than subsidizing broadband deployment.

MR. KNAPP: Well, I have to intercede, I

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have to be the bad guy, because I think we should probably go for a couple hours more here. But I want to thank all of you, Victor, Adam, Vint, John, Henning, Paul, and Bill, we haven't forgotten you, it was just a fantastic session, and I hope you'll be open to us following up and there may be some things we want to talk to you about a little later on. But please join me in thanking this terrific panel, thank you. We'll have a short intermission and we'll make it 12 after 11:00 that we'll start.

(Recess)

MR. KNAPP: We're about ready to start the second session this morning. Can I please have everybody take their seats? Well, thank you. We've got another great line-up of panelists here for the second session. This is focused a bit more on the technology side, although clearly there's overlap between all of these sessions on deployment and vision and the technologies. And I think everybody was here for the first session, but just as a reminder again to turn off your cell

phones, and for our speakers, we've got a five minute clock here up front, and in the interest of time, we will dive right in. We're going to shuffle it up a little bit, and our first speaker will be Doctor Paul Henry.

DR. HENRY: Thank you very much, Mr. Knapp. I come to this panel with about 40 years of experience in the research laboratories of AT&T and of Bell Laboratories. I bring a -- I have a variety of experience in different kinds of communication systems, and over those years, I've seen many ultimate solutions come and go. So I am not fixed on -- I am not obsessed with predicting any particular winner, and I'm -- as a disclaimer, I'm not a spokesperson for AT&T.

What I hope I can do in this panel is, using the experience I've had in these various research adventures, I hope I can contribute at least some insight as to what different sorts of technologies are capable of doing or incapable of doing, because one of my primary messages is that there are a lot of varieties out there to help us

achieve broadband access, and to my view, there is no silver bullet. Could I see the next slide, please? What I'd like to do is just outline on this slide very, very quickly those considerations that I think are important when we try to decide which technologies are good and which are not so good. And, of course, the first consideration is, who are we trying to provide broadband access to. An issue there is the unavailability of access to some people versus the unsubscription of broadband access by those people to whom access is available. And from a technological point of view, of course, it's the first one, the unavailability, that's important to me and the one that I will try to address.

As you also know, in boat number two, broadband access means different things to different people. And depending on what it is we want to provide with broadband access, there will be different demands placed upon the technology and different technologies will appear to be better or worse. And so, of course, we need to

settle on what it is we're attempting to provide.

These technologies are frequently characterized in terms of raw bits per second. But one of the things that I want to emphasize here is that in addition to raw speed, there are other issues often labeled under quality of service which can dominate the simple raw speed issue. And in particular, one of the matters which isn't discussed frequently which I think is so important is this notion of sharing. All networks, sooner or later, share their resources, some implicitly and some explicitly. But depending on how the sharing is done, and depending on the nature of the traffic which is being carried, the user experience can vary greatly.

So one of my messages, in addition to there being no silver bullet, is, it's very important for us to understand how we will go about implementing sharing of precious resources in our broadband networks. Where will be provide these resources? Well, of course, there are urban

situations and there are rural situations. And again, different technologies come to the floor, depending on what we're trying to do.

In urban areas, we're trying to maximize the number of users per unit area, per square kilometer. In rural areas, on the other hand, what we like is technologies which can cover large geographical areas at relatively small cost. And in that case, for example, wireless tends to show its strength, whereas in urban areas it might not be as strong. We can comment on this perhaps a little bit later. So how are we going to do all of this? There are many different technologies. Can I see the next slide, please? There we go. I'm just using this slide to point out that there are lots of different ways, lots of different ways to skin the broadband cat. And each one of these technologies outlined here is capable of providing broadband service depending on how you define it.

We haven't talked much, for example, about satellite service, but high altitude satellites can provide broadband broadcast, which

might, for example, take the load off terrestrial networks in a rural environment.

In any case, there are many, many different technologies available. Some use existing infrastructure, like broadband power line, and might, therefore, in some sense, seem to have an economic advantage; others require the construction of new infrastructure, for example, like Fiberpon.

In any case, each of these technologies needs to be tested against the use cases that we establish for what constitutes broadband. And after testing all of these technologies against these use cases, we then proceed to decide which of them gives us the biggest bang for the buck in the environment we're investigating. Thank you.

MR. KNAPP: Thank you, Paul. Mark.

MR. DEPIETRO: Thank you, thank you for the opportunity to speak here. My name is Mark DePietro, and I look after strategy and business development for Motorola's home and network business. And within the context of that

business, we provide equipment and services that cover the spectrum of voice video and data solutions, we provide sat top boxes, cable modems, CMTS equipment, pon equipment, and we also run a couple services, and in particular, we run some authorization services on behalf of some small operators, and it's in the context of that service that I've been able to observe some things that I think need to be brought into awareness in the context of this discussion, and that is that the broadband services really have to exist and be considered in the context of the other spectrum that is available to the operators.

And, in particular, if you look at some of these small operators, some of their cable plants only go up to 550 megahertz. In fact, the authorization service that we offer, well over half of those customers top out at 550. And if you recall the slides that John Chapman put out in the previous session, that's typically where digital begins. So in order for these operators to be able to deploy broadband and then strengthen

deployment, they have a problem, they're landlocked with these analog services. So what we really need to do to be able to, in the immediate future, help them go faster and actually be able to offer broadband, is find a way to help them accelerate the transition from analog to digital.

Now, one way to do that is by making available to them very lost cost end devices that will help facilitate, because if you contrast the 550 megahertz system to a broader one, if you have more band width, you can actually carry signals, and that gives you breathing room to do a transition.

If you only have 550, you really can't do that, and every time you want to add a digital service or a broadband service, you have to take away an analog video service, and that is an immediate and harmful potential decision relative to keeping them in business.

So one thing that we think is very near and immediate is, granting some waivers for these very low cost digital transition adapters that

will enable these operators to actually do the spend that's going to be required to do the analog to digital transition that will make possible the offering of these faster broadband services. And I mean if you think about it, every analog channel consumes six megahertz, that's an opportunity cost of on the order of, using lazy style math, about 40 megabits per second of internet opportunity cost. The other thing that we think, along those same lines of band width being very precious, other technologies like switch digital video that will further free up opportunities to deploy broadband, and just by way of introduction, the switched technology, instead of transmitting in a broadcast fashion the TV services all the time, only do so when there's demand.

And to the point that I think Vint made in the previous panel, it carries with it a couple strengths that, you know, pure point to point does, in a sense that it's multi cast. So a number of different subscribers can benefit from a single transmission, but it also has the

characteristics of unicast such that it's only present when at least one person has asked for it.

So we think that the recent actions from the Commission encouraging those services need to be kept up, and similar technologies that really are aimed at band width conservation, very important to continue to encourage those. And then I think the third thing that I would say is, you know, given that cost is an issue, especially for these smaller operators, anything that adds cost, but has questionable benefit going with it, any regulation in that arena should be looked at with a fresh set of eyes, and there's two in particular that I can mention, one of them is the requirement to burden every digital set top with a cable card, that represents an increment cost that could be redirected towards broadband. Another one is the requirement for high definition set tops to carry a 1394 interface. Both of those are costs that arguably don't have a lot of benefit going along with them and represent opportunity costs relative to capital needed for broadband

deployment. And I think I'm going to end about 20 seconds early and defer to the gentleman on my left here.

MR. KNAPP: That's great. Thank you, Mark. And we'll go to Marc.

MR. GOLDBURG: Well, thank you. Good morning. My name is Marc Goldburg, I work with a company called ASSIA, which develops network optimization tools for DSL operators. Could I have the slides, please?

You know, we were asked as participants to highlight several issues of key interest to the FCC in the course of considering broadband. So on the first slide, which is the next one, I've tried to address three issues in the context of fixed access and also in the context of consumer access, so I'm going to limit my comments to that point. Next, please. So, you know, today there's basically three principal options for wired or fibered fixed access. There's pure fiber, fiber to the home, there's cable, and there's fiber to the node, plus DSL. And sort of similar to Doctor

Henry here, I tried to come up with some estimates for what the through puts were of these technologies. You know, fiber to the home systems today, there's an optical fiber, maybe GPON goes to a network node that's split 32 ways, and you can just divide 2.4 by 32, so you get sort of 75 megabits per second sustained per customer.

Cable is a shared medium, it's a little different sort of calculation, but you take the peak speeds, which will be at least 155 megabits per DOCSIS 3, divide that by some appropriate over subscription factor, and again, you end up with a number of about 22 megs.

DSL today, the current version of the technology is something called BDSL 2, that's being deployed today to provide 50 to 75 megabit per second type rates, and the next couple of years, some standards are completing that will allow us to go well in excess of 100 megabits. So the point of this is that, I mean as Doctor Henry said, there's a number of sort of good high speed alternatives for broadband, and so the next issue

is, what are the appropriate selections. And if you could bring up the next block. You know, each one of these selections, they all offer high speed, but they all have different cost structures, especially considering geography, demographics, what infrastructure is already available in terms of copper and DSL, excuse me, copper and fiber.

One thing about the U.S. is that, overall, we have a relatively low population density compared to places in the world that are actively pursuing pure fiber to the home deployments.

There's a lot of talk about fiber to the home. In most places, the operators are falling back to a combination of fiber to the home and fiber to the node. Places like Korea, Singapore, which either have or will have pervasive fiber to the home, have population densities that are much higher than the U.S.

And if you look at places similar to the U.S., in terms of, you know, geography and

infrastructure, we have a couple case studies you could look at. There's Verizon's, you know, excellent FIOS service versus AT&T's Uverse service, which is BDSL. Based on published numbers, there was about a 5X capex difference in the deployment cost. So I'm just focusing on capex for the moment. The OFCOM, which is the United Kingdom's counterpart to the FCC, has recently concluded a study. Again, I'm looking at fiber to the home versus what they call fiber to the curb, but essentially fiber to the node. Again, they've concluded there's probably a 5X premium in the UK for a national fiber connection.

And so I think, you know, and Paul and I did not collude on our comments, I think the right answer is, there's going to be a mix of technologies.

The third point, if you could bring that up, I think is the one that's maybe less obvious and actually was mentioned by Doctor Frost from NSF earlier, which is that once one made the technology decision, the things that actually

drive the performance of the network and the services the customers receive, and, in fact, probably the economics of the network are, what are your deployment and network management practices once you've made your core technology choice. Next, please. Can I get the next slide please? So here I'm just going to give you a DSL specific example. So we've seen the very high peak rates on the previous slide. We all know that in the labs, you know, people demonstrate hundreds of megabits or gigabits and sort of claim success, but those same rates are never seen in the real world for economic reasons and for technical reasons.

The technical reasons are that there's all sorts of impairments. So in the case of DSL, it's bad copper, it's interference from the appliances in your home, it's the fact that signals get weaker as the loop links increase, and these are all things that an operator has to manage to try to get close to those peak rates while at the same time having an economic system.

Next, please. One more. In fact, you can just bring the rest of the bullets up.

I think the point here is that every technology, when the operator goes to deploy it, they've got this quality versus coverage or capacity versus coverage trade- off and depending on the network technology practices that the operator chooses, you can move that trade-off curve, you know, greatly extend the possible range, greatly extend the possible data rates, and thereby be able to offer more services to more customers more economically. But the technologies that the operator chooses as part of their deployment practices really determine that in addition to the original technology choice of fiber versus cable versus DSL in this case. Thanks.

MR. KNAPP: I'm going to jump back, and Dave, if you're ready, jump in.

MR. BURSTEIN: Hi, slides are handy, if they get them up, but let me start talking so I don't waste my time meanwhile. I'm Dave Burstein.

I had a very what I think was a nice presentation about how, if you're going to talk about networks, you can't live in the past.

Morse Law works and will continue working for the next ten years. Networks take three and five years to build, they're going to run for ten and 20 years. So anybody in the real world thinking about networks, the ones these guys are selling to, thinks three years ahead, looks at the technology, and plans things out in a world where there will be 92 percent of the United States having ten megabits of wireless available to them, 80 or 90 percent of the United States having 50 megabits on DOCSIS cable available to them, some have even more from FIOS and fiber and so on, and works starting with that. My slides aren't found? Okay. I'll improvise just fine. I'm going to switch off very quickly, though, because something much more important came up in this. First, what Mark said about SDV, switch digital, turns out to answer, makes irrelevant a question that came up in the last session. There

is no longer an issue about how many channels you put on a cable network, or there won't be in 2012.

Technology has fixed that, the switch lets them have literally 5,000 or 50,000 channels available at very small cost that they don't have to worry about, so they can take part of it for data and use it, and they have more than enough for all the channels, you know, 500 HD channels, that technology works, he sells it, Time Warner is putting in a whole lot, that's on longer an issue.

Typical example, if you know the technology, you look differently. That goes right back into an FCC issue of whether or not you have a must carry LP TV that's brutally expensive right now, so it didn't happen, even though three Commissioners wanted it. It's trivial in 2012, it should automatically be policy.

This is typical of what I learned and why I'm here. It is ridiculous for me to tell you what DOCSIS 30, when the guy who invented it, John Chapman, taught me, was on the panel before, but unlike most of the people you're hearing, I earn

my living as a reporter, in fact, I sell ads to that guy over there, and so on, and I have to find out what's actually happening in the real world, which is why I'm going to switch this one around and go to something very different.

Rob is going to hate my guts and probably try to keep me away from the FCC from now, because I'm turning around and saying that most of what he said was nonsense and will result with fewer than half as many unserved being reached by the broadband stimulus and blowing a very large percentage of the $100 or $300 billions he's allocating in the broadband plan implicitly. And here's what's going on and why I say that.

I checked with David before about whether or not there are any congestion problems on FIOS, and the answer from Verizon is no. The same thing is true on AT&T Uverse, the same thing is true on nearly any decent large DSL or fiber network.

So we just heard a whole big session, well, a big part of the session, talking about how

you deal with congestion and how you have to arrange network economics and incentives and so on to deal with the congestion problem. It turns out it's non-existent on most of the networks we're talking about. Second, we heard Marc over there, Marc was just saying that the best way to get to the unserved, and we talked this the last session, the second thing they should do in the broadband policy is, take those little cable companies, three million of the seven million unserved belong to folks like them, for a quarter of the stimulus money, you can give them all 50 meg, and Marc will be delighted to sell them the equipment. This is a no brainer, nobody is talking about it, that's why I'm throwing it at you really hard and offending Rob.

The second no brainer is that what I'm hearing from everybody is the problem for most broadband networks, is the cost of band width. There are two ways to bring down the -- there are two ways to bring down the cost of band width; one is, spend $20 or $40 billion directly or

indirectly over building the fiber in place, the other is getting serious about special access, and make sure that Laramie, Wyoming doesn't pay $100, for it cost $10 to deliver because of monopoly.

Finally, why Rob is going to hate me; Rob talked about theory, he talked about ideal cases, I talk about real world. Real world, as Vint Cerf mentioned, has weak competition. Most of the two-way models don't apply in weak competition. Most of the incentive models don't apply in weak competition. The biggest problem that Jules has, thinking of the FCC, is, he thinks he can solve problems with competition, which I would love, but we're only going to have two land line and high speed networks in the U.S., we've got to come up with a policy that works. Thank you. And sorry for the rude things.

MR. CURTIS: Real quickly, love you, Dave. We're --- to be clear, two things, just so everybody is clear, not my point of view was being provocative about prevailing Wall Street point of view, that's number one. Number two, this is a

fact-finding mission, all right, so want to hear and get on the table all of the different points of view, and, you know, encourage that continue. I'm not offended at all. This is exactly what we're supposed to be doing, so thank you.

MR. BURSTEIN: And I told Rob it wasn't personal, but I really think these are big issues, and I'm seeing -- I sat here for a day already yesterday hearing 90 percent of stuff that has no application to the real world. If you had the real Wall Street people in here, you'd hear very different things than most of what you heard, because they also have to deal in the real world. We need to work there.

MR. KNAPP: Okay. Let's see where we were. Jason.

MR. LIVINGOOD: Sure; thank you very much. Thank you, Mr. Knapp. I'm honored to participate today. My experience with broadband began in 1996, at the very beginning of the broadband residential internet market. I joined a 25 person team that was working to transform cable

model technology from a very small technical trial into what would be a scaleable broadband service that could be deployed across our entire footprint.

That seemed at the time like a huge gamble, particularly to many analysts. Even Andy Grove from Intel at the time said that there was little reason to expect that cable would be a viable delivery system for internet access. So I can say that we were delighted to prove so many skeptics wrong.

In those early days, we pursued the idea that someone in their home could have affordable service as fast or faster than a T1 line, which at the time cost thousands of dollars a month. That was totally innovative on our part, and it seemed, to me, that the introduction of broadband would be transformative to our economy and our world, which I think has been the case. Since then, Comcast and other cable companies have invested tens of billions of dollars in what are called HFC or hybrid fiber coaxial networks, which I'll describe

in a moment, that are on the slide.

The network we built now serves over 15 million customers of high speed internet service and passes over 50 million homes. It might be helpful to see a picture of what these look like, so this is the first slide. HFC is quite simply a mix of fiber and coaxial cable. And as you can see here, we run fiber from our backbone and regional networks all the way down to cable modem termination systems.

Those CMTS' are out in -- then pass signals out to our nodes, which are also connected via fiber and located in local neighborhoods. And from there, we use coax cable to carry service all the way into the home.

Today a node serves between, on average, 250 and 500 homes, though that depends and varies based upon population density and band width demand. Over the years, we've split these nodes time and again, and we continue to do so to stay ahead of demand. And as you heard from John and some other folks, in addition we now have some new

tools called channel bonding which I'll talk about in a moment. The massive investments we started making in the '90's to convert our networks to two-way HFC made the high speed internet service that we have today possible. So did our innovation in creating the data over cable or DOCSIS spec that we have. That's evolved into the DOCSIS 3 standard today, which we are very aggressively deploying and will be completed in our network next year.

And if you turn to the second slide, you can see a little bit about DOCSIS spectrum. DOCSIS spectrum is divided into both upstream and downstream channels. A single downstream has the equivalent of six megahertz of capacity and transmits at a speed of 38 megabits per second downstream and 27 upstream.

With DOCSIS 3, as you can see here, we can now combine or bond multiple channels together, and as a result, we'll now be able to bond four downstream and four upstream channels. This will provide us capacity to provide over 150

megabits per second downstream and over 100 megabits per second upstream to customers.

In addition, vendors are now testing eight channel bonding that could provide hundreds of megabits per second, and I see no limit in the next few years to bonding advances that could potentially enable gigabits per second. But in order to be able to bond more of those channels, we need to be able to make more efficient use of the spectrum that we have in our network today. So it's, therefore, critical that we shift today's analog video transmissions over to digital as rapidly as possible.

The FCC should keep this priority in mind as it develops the broadband plan, ensuring that cable operators have the flexibility to deliver higher internet speeds while at the same time introducing and enhancing other services.

We've built a very robust and expandable access network, as you saw in the previous slide, but it's worth noting that we've coupled that with a very capable regional and national backbone

network that we think is one of the leading converged internet voice and data networks in the country.

And while we deliver great speeds to our customers, we also want to make sure that those customers are getting the full value of those speeds by educating them about the need to upgrade their equipment in their homes to be able to take full advantage of the speeds that we're talking about here. In closing, I hope we've explained a little bit that cable has brought us nearly ubiquitous broadband coverage in the United States, and that DOCSIS 3 in particular allows us to offer a world class state-of-the-art service. We're ready and able to deliver even more speed and other useful features in the future, and in particular, the near future. And we are committed to continuing to invest in the network and innovate to satisfy customer demand, both now and for many years to come. Thank you.

MR. KNAPP: Thank you, Jason. David.

MR. YOUNG: I'm David Young with Verizon

and I'm very pleased to be able to be here today to talk about our FIOS deployment. You've heard a lot of mention of it over the last two days, and we are extremely excited. It was about five years ago that our executives made the decision to do something pretty dramatic and different and unexpected.

When we first announced that we were going to do this back in 2003, there was a lot of skepticism that we were going to do it, and then when people realized that we were serious about it, there was skepticism about whether we could actually be successful in doing it. But over the intervening five years, it really has proven to be transformative. We've transformed the access network from copper to fiber, running fiber all the way from our central office to the customer's home using a passive optical network. And when we first rolled it out in 2004, using the BPON technology, that provided a shared 622 megabits per second to 32 homes.

We've since upgraded to GPON, which has

a combined capacity to those 32 homes of 2.4 gigabits per second, and the standards are being worked on now to move to the next generation PON architecture, which will provide a ten gigabit per second shared capacity. And we expect those standards to be completed in the next year.

The service offerings were five, 15, and 30 megabits per second when we first rolled it out in the downstream direction, and two and five megabits per second in the upstream direction.

Those have since evolved to now the entry level speed is 15 megabits per second down and five megabits per second up. The sort of mid tier is 25 down and 15 megabits per second in the upstream direction, and our top tier today is 50 megabits per second down and 20 megabits per second in the upstream. So the home network, as we deployed this, needed to also be able to support the higher speeds that we were delivering over fiber that, you know, we hadn't been able to deliver over DSL or other technologies, and so it was important when we began doing this to focus on

a broadband home router that would be capable of supporting the very high speeds that we planned to deliver with fiber.

And in doing so, we've created a home network and really transformed the home network environment, as well, and we've done this by providing a home router as part of the service that offers WIFI, as well as wired connections within the home. And it also connects our set top boxes using IP over the coaxial cable in the home.

And so the high speeds, both upstream and downstream, I think are transformative to the customer experience, because, as you heard in the previous panel, there's a need for greater symmetry and a need for end users to be producers of content, as well as consumers of content.

In 2005, we added video to our product. Originally it was just FIOS internet service that we had offered. In 2005, we began offering a FIOS TV service. We basically overlaid an RF video feed on the fiber that is delivered to home, similar to a one-way digital cable system. The

key difference is that all of those channels, all of that capacity is available for video programming. We don't need to use any of that for DOCSIS or any other things. And so that's allowed us to transform the television experience by providing over 100 HD channels in the market, an all digital service. But also transformative in the TV space is bringing IP to each set top box, and so the interactive and on demand capabilities are all IP based.

We've also got something called widgets, which are applications that run in the set top box. We initially came out with our own, which were weather, sports, news, traffic, those sorts of things. We've since introduced Facebook and Twitter as widgets, and we've announced that we will be launching -- releasing a software development kit and opening that up for a third party development in the fourth quarter of this year. We've actually got a web site, code.verizon.com, that people who are interested in developing those widgets can go and start to

learn more about it.

And just as an aside, we think that, as we roll out LTE on the wireless side, that this will be as transformative in the wireless space as FIOS has been in the wire line space. Ultimately, ubiquitous broadband I think is going to have the power to be transformative to the country for the applications that have been talked about, health care, energy management and those sorts of things, and so we share the goal of bringing those benefits to everybody. Thank you.

MR. KNAPP: Thank you, David. Geoff.

MR. BURKE: Great, thank you. I think really they've placed us together here, David, because we're kind of the one two punch I believe here for talking about fiber. Your representative of one of the largest operators in the country. My company, Calix, is actually the largest broadband service provider to the tier two and tier three operators, so all the rural providers around the U.S. Today.

Basically, if you were to set back and

take a look at our business, our business basically represents about 40 percent of the rural service providers in the U.S. Today, and amongst those providers, they're actually providing millions and millions and millions of broadband access connections. Go to the next slide, please.

What I'd like to do is really talk about one facet of that, because I think it's important for you to understand that not only are we the primary DSL access platform provider to rural service providers, but we're also the primary fiber solution provider to them, as well. And as of right now, what we're seeing in the market is basically about well over 375 of our customers are actually actively deploying fiber all the way to the premises in these rural markets and being very successful at it.

So one of the things I think is interesting about our perspective is that the rural markets tend to be the canaries in the coal mine, right. They basically are the folks that are unencumbered by the scope and scale and

arguably the bureaucratic challenges that some of the largest tier one operator's face. And as a result, they get to experiment with new technologies and arguably run faster.

So you can look at cities amongst my customer base and find, you know, them more wired, or at least as wired, or in many cases, more wired than any of the major urban areas across the U.S.

So what are these canaries telling us? Let's get down into some of the details here. Basically what we have seen is an average cost per home pass of about $800, not a lot higher, but just slightly higher than what David is probably seeing at Verizon, and about an all in all pulling the fiber and those sorts of things for homes served at about $2,000 per home. And when I cite these figures, I'm really talking about maybe 25 to 50 person density per square mile in those particular areas.

One of the things that helps out this business case is the fact that, in these areas, we're seeing 50 percent plus acceptance of these

services, and we'll probably get into some of the details of how that happens a little bit later in our discussion.

One of the things I think is very important to understand, though, is that I couldn't help marvel when I was listening to David rattle off application after application after application that is now either being rolled out or soon to be rolled out over the Verizon network. That's exactly what our customers are doing, as well.

They really feel unencumbered by the types of, whether it's IPTV service, advanced RF or radio frequency over cable services they can put over these networks, and other new telepresence or telemedicine or other types of applications that could very easily be overlaid in this environment. Next slide, please. So where are customers leading us and what are they telling us when they're talking about us? Well, certainly what we're immersed in right now in the country is a movement from a textual and graphical based

internet and one that is predominantly an all video domain. And when I say video, I'm not just talking about IPTV or RFOG, I'm talking about really rich, interactive content that basically is going to provide everything we do.

I just actually stepped off the plane from California last night, and as I was leaving, the big item was, everyone was turning their textbooks into digital textbooks, and they're predicting that within the next five years, 90 percent of all learning taking place in the state was going to be digitally based, right, not because -- well, partially because there was a cost savings, that certainly was the initial driver, but the other side of it was, the kids just didn't get traditional textbooks, right.

I think this is a great indicator of what we're going to see going forward in terms of basically the amount of Unicast traffic, the amount of video that's going to be in the network, and we need to ask ourselves, what types of technology is going to have to be in place to go

and address these issues. So what does this mean from a policy perspective? Well, I think there's a couple of key takeaways here; one is that when you build out an access network, this is a generational issue, right, we're setting policy here today, right, so do you want to focus on things that are giving you -- really have reached the point of diminishing returns, or do you want to put an infrastructure, like as David alluded to, contributing application after application after application, you don't have to worry about these issues going forward in terms of flexibility.

The second thing is that, as we look at those applications, they are going to be all fiber in the future, right, and so those sorts of elements need to be taken into account when we're thinking about this. Wireless is clearly advantaged. These LTE networks are an advantage by a fiber feeder going into it. So how do we afford it? Well, I think that's one of the interesting things we're going to address as we go

through today. So thank you for your comments.

MR. KNAPP: Thank you, Geoff. Stuart.

MR. LIPOFF: Okay. Good morning, everyone. In December, 1995, I began a journey that's still a work in process. At the end of the year in '95, I was hired by the MCNS consortium of cable operators to manage the development of what is now called the DOCSIS 1.0 series of cable modem specs. Just one year later, after starting at the Western Cable Show, the first prototype DOCSIS compatible modems were demonstrated and commercial product appeared very shortly thereafter.

As the first widely available, always on, high speed residential internet access service, and given that DOCSIS compatible cable modems now serve 40 million subscribers and are available to 92 percent of U.S. Households, by any measure, the DOCSIS technology is certainly a success.

I think it's important, however, to return to that one year during 1996, when DOCSIS 1.0 was being developed, to understand why DOCSIS

has been successful and why it is likely to continue to offer advantages over competitive technologies, not just for service providers, but the consumers alike. And the historical perspective I want to share with you is the vision that guided the design of DOCSIS that's been maintained in the various generations since then. The one year development period for DOCSIS was actually very rapid compared to communication systems of comparable complexity at the time. But it actually could have gone much faster if the only goal were to provide unmanaged best efforts access for the high speed internet. In fact, there were several competitive products on the market that we could have just adopted and kind of bypass the whole process to give us internet access.

But the vision of the cable MSO's and vendor participants who participated in the development of DOCSIS understood from the very start the project had to have a successful specification, had to be both flexible and future

proofed to evolve as rapidly and as unpredictably as internet itself.

To satisfy these goals of flexibility and evolvability, the DOCIS specification placed unheard levels of intelligence at the edge of the network, in the cable modem itself. Some critics suggesting adding this complexity of secure transmission, remote provisioning, remote monitoring, hooks for quality of service management, and the ability to download new firmware would slow down the standards process and drive up the cost.

Well, cable modems today are $50 at retail, and given the historical rapid development cycle, the critics were wrong. Today we find the extra intelligence building the DOCSIS devices supports not only the original high speed best efforts access to the internet, but also enables new revenue streams and operating cost savings with very small additional capital investment. Such benefits of leveraging some capital investment is clearly good for the cable

operators, but the point is often lost, is it forbearance from legislation regulation that would inhibit leveraging these costs would also do great harm to the consumers and work contrary to the stated goals of the administration to expand broadband access to under served and unserved areas.

It simply and basically is about the economics. MSO's have invested already in driving cable model services to 92 percent of U.S. households, precisely because the multiple revenue streams enabled by new services such as telephony, and operating cost reductions enabled by network management technology such as DOCSIS -- Gateway, provides the equivalent of a government subsidy to derive and expand broadband services.

The management capabilities enabled by intelligent DOCSIS offer much more than walled garden services such as MSO telephony, however. It was described in the panel that preceded this this morning the vision for broadband services and applications goes beyond largely a symmetrical

delay and sensitive web browsing. What's common to several visions is a mix of web pages with new multi media services that can only provide a satisfactory user experience if their quality of service managed.

The fundamental fact remains that all internet service providers travel over a shared network. And while the points of aggregation vary somewhat between DOCSIS over HFC, as compared to DSL over copper and FIOS over passive optical network, all these networks share this morning's vision -- cannot share this morning's vision if they're not allowed to manage the end user traffic and provide quality service.

The challenge for the Commission and for Congress is to craft regulation and legislation that provides fairness to all parties of interest, but does not inhibit the network operator from being allowed to manage the network to prevent abuse, deter crime, piracy, facilitate experimentation with new services, and rapid service creation.

So I'd like to conclude by rising to the challenge that was put to all of us by the panel organizers. We should emphasis some important points that we want you to take away, and here's mine. If you want to increase access to broadband by unserved households, at the same time facilitate the proven free market process of rapid creation of new and innovative services, you must allow the network operator to manage the network with differentiated quality of services. Thank you.

MR. KNAPP: Thank you, Stuart. You know, often we'll hear about, you know, other parts of the world where they've got targets for data speed, data speeds get thrown around a lot, 100 megabits per second, gigabit per second, et cetera, et cetera, and the speeds really vary. I mean this is a benchmark of, well, reported as a peak speed, but then when I get further away from some of the networks, the speed goes down.

We talked in the last session a little bit about transparency and how you provide

information to consumers so they can make informed choices. As we think about a national broadband strategy, and speed isn't the only element, of course, it's also things like, well, how long are you going to be on in your location, how does that enter into the equation? What should we be thinking about? Is this relevant, should it be defined some way, is there a target? Doug, why don't I start with you?

MR. YOUNG: You know ---

MR. KNAPP: Excuse me, David. I'm sorry.

MR. YOUNG: Sure; the challenge is that, you know, the particular speed that's required varies depending on the application and the particular user's need, and the different technologies have such vastly different characteristics, so, you know, with fiber, you could set the target as high as you want and you could meet it with wireless or, you know, with other technologies, there's going to be too many -- too much variability.

So I think it's good to measure it, and so I think that, you know, the things that the FCC is doing to measure broadband, the 477 reporting process, for example, and the changes that were made to that, I think are going to be helpful in more accurately capturing what's out there and how it evolves over time. But as far as having a particular goal or target, I just don't know how you would go about picking it.

MR. LIPOFF: Can I make a comment to --

MR. KNAPP: Yeah, Stuart.

MR. LIPOFF: I think this is obviously a broadband panel and that label maybe means many things to many people, but if you look at both the Verizon network and the cable networks, the HFC networks that are being developed, they also support broadcast video, and it's really important to ask this question about, you know, what are the band width requirements going in the home to think about the applications.

And where you have large numbers of people watching the same channel real time,

whether that's coming streaming or it's coming mpeg over QAM, that does not encumber necessarily the bursty kind of traffic that you might want to have associated with things that require unicast two-way types of networks.

And so you really do have to look at the applications. It came up I think on the panel this morning. There's some applications like game playing where latency is the most important thing, not the peak speed or the traffic. There are applications like voice telephony and video conferencing where you care about stream continuity because you're doing things that require that the stream not be interrupted or the user experience is compromised.

When you're doing web surfing with multi media rich pages, you care about a really high speed burst, but then you're sitting there for a long period of time not doing anything. When you're uploading a file for backing it up, that can be done late in the evening. So I don't think -- unfortunately, it's complicated, and I don't

think just looking at the peak speeds associated with any one of these technologies is the thing you want to get into. You really want to think about what are the capabilities of the network to handle these flexible different types of traffic types and how can other things the network is carrying such as broadcast content or multicast content perhaps offload some of these other applications.

MR. BURSTEIN: It turns out -- there's an interesting way to look at it that gives it what I think is a pretty good answer. Think like an engineer, not like a Washington policy-maker. Look at what's practical and economical and can be done.

It turns out that we're in much better shape than most people realize because David Young's company is going to bring four to ten meg LTE to 92 percent of the United States in 2013. So it's perfectly reasonable to say we should have four to ten meg to at least 90 percent of the United States, because that's going to happen even

if government does nothing, and that's higher than most numbers. Even more dramatically, the DOCSIS 3.0 really is that good, it's not as good as fiber. There's good arguments back and forth, but it should be the baseline. Mark, am I off base saying that DOCSIS 3.0 is going to be able to bring 50 meg to most homes somewhere between now and five years from now, not all homes, but most?

MR. DEPIETRO: No, not at all.

MR. BURSTEIN: Okay.

MR. DEPIETRO: No, you're not off base.

MR. BURSTEIN: It turns out that the cost of speed -- and this is a good baseline. The cost of speed is talked about in policy circles that don't understand that speed does not cost enough to notice, band width is not free, but it's so cheap that you can give 50 meg for the same price as you can give ten meg, Source, CTO, Comcast, and that that is a reasonable goal to make happen, and how you do that in policy, I defer to the folks on my right.

MR. KNAPP: Jason.

MR. LIVINGOOD: If I could just add a couple of thoughts to that. I think that there are two other things in addition to latency that you should pay attention to, and one is security of the network, and the other would be the scalability of the address base. So in terms of scalability, some of the earlier panelists talked about mobility, a lot of those things require things like ITV 6, those are important things to support. From a security perspective, you know, bots and spam and other things are a real problem in networks, and those things need to be kept in mind. And there are some near term things like DNSSEC and other initiatives that the government is already encouraging that I think are important to continue.

But lastly, I would say that, you know, on all of these points, I would recommend that you have some quantitative metrics, that you're trying to figure out what are you trying to achieve with the plan and sort of, you know, look back periodically, you know, annually, bi- annually, at

where are you on those quantitative metrics, whether they're speed, you know, penetration, availability, so on. I think those are important goals.

MR. BURKE: I think, you know, David has thrown out some numbers here, and I think it's interesting to think back at what I believe we're trying to achieve here today, which is basically to set policy for not just the next three to five years, but for a decade and beyond, right. So to the extent that there may not be an actual number, I think what I would encourage everyone here on this panel to be thinking about is, whatever you set it at, set it high, right, because the reality is, whether we're talking about latency and its relation to cloud computing and gaming, right, whether we're talking about a movement from a broadcast unicast environment, whether we're talking about all of the deeper levels of that which get into packet loss and -- and those sorts of elements, many of these elements can really be facilitated greatly by setting a bar high with

regard to broadband speed delivery, right, and ultimately allowing yourself to fill that in the most economically feasible ways for service providers.

The second element of this is, I believe that, you know, to some extent we're arguing the speed which ultimately is going to be determined by the public overall, right. It's the public who's going to demand these speeds. And to the extent that we can extrapolate today, I didn't speak to it on my slide, but, you know, I think there's -- whether you agree with it or not, ITIF figured that there's a five meg average speed in the U.S. today.

You know, you take a 70 percent increase on that over the course of the next five to ten years, you're easily jumping into 100 meg and even up to gigabit ranges, and these are average speeds. Can we conceive of what those applications are today? You know, it's hard to, right. But by the same token, you take yourself back five to ten years, you couldn't conceive of

the applications we're trying to deliver today, right. So I think there's a -- whatever we do from a policy perspective, just let's aim high with regard to what it is and we'll naturally see a tendency towards the right solutions in terms of network.

MR. KNAPP: Before I have -- I just wanted -- and I'll get back to you, Mark, to announce that for folks who are listening out there, you can either submit questions by Webex or cars in the room. Where did Rashmi go? There he is. We've also set up an email box, FCC-events, e-v-e-n-t-s, at FCC.gov for people who want to send a question by email. And with that, I'll go to Marc.

MR. GOLDBURG: So on this issue, I think it is possible to set sort of meaningful metrics, metrics that are meaningful to the consumers for broadband performance. I mean, yes, the requirements of each application are very different, some are latency sensitive, some jitter, but, you know, as Vint Cerf said earlier,

actually if there's enough band width available and there's some head room in the network, the latency and jitter problems are going to solve themselves. So maybe it's adequate for the consumer perspective just to say, you know, you're up to ten megabit service, well, you should be provided at least 80 percent of that as measured by FTP or some other, you know, pedestrian file transfer technique, and that is meaningful to the consumers. If networks are engineered to sort of reliably provide that to them, then probably many of the latency and jitter type issues would go away.

And, in fact, Ofcom, I keep coming back to them, but in the UK, they do have sort of a broadband truth in advertising standard that's been published. But I'll just mention one other thing which sort of struck me as I was preparing the slides and also listening to the people here on the panel, which is that, you know, all these technologies we're talking about are basically pushing fiber closer and closer to the customer.

So, you know, BDSL is fiber to the node or to the curb.

Jason was talking about -- well -- will be cell splitting, but MSO splitting and sort of, you know, putting fewer customers on each cable segment and moving the head of the cable segment closer to the customers, and in the fiber to the premises case, you know, you're all the way there.

So it seems to me that, you know, as that happens, the issue is less and less about access technologies and more about, you know, in the performance of them, because they're converging and they're all very high, and it's hard for me to imagine applications in my home that can generate hundreds of megabits or even gigabits that I need to send somewhere.

So the real question is, are we really looking at, from an engineering perspective, at solving problems in the core network? Is congestion there really going to be the thing that determines whether we see -- whether or not we see the peak advertised speeds rather than limitations

on the access.

MR. KNAPP: I had a -- let me throw this question out there that came in.

DR. HENRY: Can I --

MR. KNAPP: Yeah, go ahead, Paul.

DR. HENRY: I have one comment on the previous one, if I may.

MR. KNAPP: Yeah, sure.

DR. HENRY: Just a very brief one. I understand that this is a panel on fixed broadband access, but in the wireless domain, fixed and mobile, of course, tend to become very much confused or mixed. And so one of the recommendations that I would make to the FCC as it's considering policy is to recognize, as we already have, that what you want to deliver in terms of broadband depends on the application that you're attempting to deliver, and the requirements on the technology vary accordingly. But, therefore, as we consider which applications need to be encouraged, I would ask that the FCC recognize that there is a steady migration of

broadband services, as well as voice, from the fixed domain to the mobile domain.

And, therefore, I think it is important to, in the context of studying the different applications, to try to understand which one of those are likely to appeal to people who have mobile devices, for example, such as an iPhone, and to adjust broadband policy, recognizing this migration into the mobile domain, which will almost invariably have a smaller band width capability than the fixed domain.

MR. KNAPP: The question that came in via email was, does the panel have a common view as to an ideal high speed internet access through put range, megabits per second, for an individual end point user beyond which the user perceives no further value; I can kind of guess what some of the answers might be. Yes, David.

MR. BURSTEIN: Again, I'd like to go to the data. Thirty meg is probably enough for anything I would want to do; 50 meg is darn good, in fact, at that point, net neutrality and latency

problems and so on essentially disappear; but people who disagree with me include 30 percent of the users on a major Japanese system who get 30 meg by default, remember, the U.S. is behind on this, and actually pay a little bit more to get 100 meg, so that whether it's important or not, clearly, there's a lot of people who think that if it doesn't cost too much, they want the higher speeds. That's JCOM Cable, which is owned by Liberty, incidentally.

MR. LIPOFF: Again, I come back to a theme I said before about it being application dependent, but let me get specific. Uncompressed HD TV today is about 19 megabit per second rate, you know, with the higher compression half or a fourth of that. So, you know, if you're thinking about a unicast video with VCR type performance, and you know, how many eyeballs or outlets are there in the home, you can multiply that up.

But if you take some of the other applications that are part of the vision, like I want to backup my hard drive, I'd like that to

appear to be a one gigabit Ethernet network back to a server that's on the network. If I'm doing peer to peer type, legitimate, non-pirate peer to peer stuff, and I'm sharing content with other users or part of a network like Voodoo, who does it, I'm going to be pumping a lot of stuff upstream, and so I'm going to be perhaps serving a lot more than what just my own eyeballs are consuming.

And I think just, if I could, to extend that to the previous question before, it's not just about congestion on the core network that we care about, because a lot of the applications and the concepts that are part of the vision are going to involve moving some of the servers of the intelligence inside the wall garden, so to speak.

Telephony is already there, but as you provide various types of services that are hosted on servers which are inside the network, it doesn't hit the core internet, so you do need to manage that congestion on the network, and people who are generating traffic that's going off into

the public internet are sharing that same access network with traffic that's inside the wall of garden.

So, you know, you have to think about the congestion occurring at different points along the way, not just on the public internet backbone.

MR. LIVINGOOD: And if I could just briefly add to that. You know, I think the -- it's a lot more than just what an individual user thinks or feels like they're consuming over the web or something like that. I think one of the earlier panelists, Henning, hinted at this by talking about other applications which I sort of refer to as sort of unintended applications or ambient applications in the home, like energy management, home safety, medical monitoring.

Other things that people aren't necessarily aware of is consuming band width or demanding band width, but potentially over time, you know, is a big consumer of band width, and might be some, you know, very interesting applications.

MR. YOUNG: And if I may, I think that one of the things that happens is, when people make a transition from let's say ten years ago, when they went from dial-up to broadband, or to higher speeds of broadband, the initial reaction may be that there's not a significant difference for a number of reasons; one, if you're, you know, if the sites that you're going to were designed for a certain connection speed, then you're not going to see any dramatic increase, and so there's a little bit of a chicken and egg there until there's a large enough market who has access at that speed for the applications to then, you know, come along to fill that. But the other is also just usage patterns. And so, you know, the ways that you use dial-up are very different than the ways that you use broadband, and the ways that you use very high speed broadband are different than the ways that you use sort of traditional broadband, and so you get the higher speed, and then you start doing things with it differently, you start watching more online streaming video

than you had before because now it suddenly works much better and you get a very high quality picture.

MR. KNAPP: What about on the low end? I mean we've got -- as we moving to other kinds of applications like energy management and so forth, it becomes -- it's not any longer somebody who just has a PC and access to the internet, it becomes like any other utility, water, electricity. What would be a baseline in terms of defining some minimum service level?

MR. DEPIETRO: Let me make a comment here. I actually think talking about data rates is probably asking the wrong question. So, you know, if you think about, for example, watching an HD video over on peg four, okay, I can do it in seven megabits per second, and if I have three simultaneous HD TV's in the house and I'm trying to download all those over the internet at the same time, you could make an argument that, you know, the 20 -- 25 megabits per second is good enough, but I think there's another whole aspect

to this, too, and that is that, you know, there's an environment now that is conducive to the proliferation of malware, and so I have all these wonderful speeds that I can experience, but my computer clogs up and I have to reboot it every, you know, couple days to get it to respond in any sort of reasonable time.

So I think rather than just keeping an eye on and making prescriptions about band width, I think it's going to be very important to, you know, adopt policies and allow flexibility with respect to getting rid of the motivations that are out there that allow malware to proliferate and actually allow people to make money off of it. I'm not sure I know how to do that, but I think that that's something that bears some consideration.

MR. CURTIS: If I could jump in and make this a little more practical question. We've got to come up with a point of view on who's unserved, unserved by what, unserved by broadband, all right. So it's a very real question that needs a,

you know, some sort of a metricized answer, and I think that's the push. This isn't really an academic debate about what the right level of service for how you think about it is, you want to be able to figure out, you know, where everybody lives in the country, what their delivered rate is, and make a decision, do you have broadband or not, and that's the level of granularity we're trying to push to get thoughts on how you define that.

MR. NEWMANN: Yeah, let me build on what Rob said, because I'd actually like to give the panel and actually anybody who's listening a homework assignment. As Rob said, we need to come up with a very real definition of broadband so we can decide who's unserved, who's under served, because that's going to determine ultimately policy and potentially money flows.

So latency we've heard talked about, we need that made more concrete in terms of what is good enough, what's not; jitter. A lot of talk about peak. I'm equally concerned about the

sustainability, however you want to define it, I've got some ideas. For example, LTE is getting compared, because it's four to eight megabits per second, with some of these other technologies. I can burst that rate, but as Doctor Henry said, everything shares at different points. LTE shares right at the edge of the network. According to public domain record by all the vendors, they agree that special -- of LTE at the transmission level is 1.8 bits per hertz. The next generation may be two bits per hertz. So Verizon has ten up, ten down that they won in the -- that means they're going to share in a sector ten megabits per second at the application level when they first roll out LTE.

On a sector basis, that's not exactly the same as sharing gigabits per second. So we need to know what does it mean about capacity allocated per user. So the homework assignments come up with, you know, how do we really think rigorously about this definition. Now I've raised several -- good, I've gotten lots of reaction.

MR. CURTIS: Good job, Stagg.

DR. HENRY: My only thought -- let me be brief first and possibly more comments later, but I think in terms of defining broadband, which is the way Julie started, I would say what is it, what is the minimum -- the baseline, as Julie called it, what's the minimum set of applications that we expect every United States household to be able to have access to, and then proceed from there. Let that be the definition of broadband. And I would just say, for example, the minimum set of applications would include, of course, elementary web browsing, it would include something associated with evolving educational policy, and it would include access -- you're shaking your head. Well, let me just finish anyway. And it would include access, convenient access to various governmental organizations, being able to deal with the DMV and the motor vehicles or the IRS in a convenient, comfortable way over the internet.

I would think that is -- those things,

to me, define what we expect every American household -- what we ought to strive for, at least that, for every American household.

MR. GOLDBURG: So another comment. I'm not smart enough to answer the broadband definition question, but I think it's worth noting that the arithmetic of sort of calculating average through put or sustainable through put per user, which is maybe the more important metric, I think has changed a lot in the last -- even in the last five years.

So historically, people would rely on the statistical multiplexing concepts and say I have a, you know, a ten megabit link, and everyone uses it five percent of the time, and so that, you know, maybe you could have 20 customers on that link and still --- they'd still each get ten megabits. Well, today, with, you know, we're not doing -- anymore, where people are streaming video, multiple video streams to their homes, and that sharing ratio has gone down substantially. So maybe, instead of 20 to one sharing, you know,

instead it's only really an over subscription of two or three that you can support and still say people are going to see the peak speed.

So for all of the, you know, shared media type solutions, I mean relative to their peak rates, so that's all wireless, just about all wireless systems, you know, cable and some others, I think the arithmetic in terms of peak to average has dramatically changed in the last few years.

MR. NEWMANN: Help us think about that. I mean we've got to come up with this definition, you know, and so help us think about it. I mean I'd love to see, for example, a filing that said these are the basket of applications and this is what it implies in terms of definition.

MR. KNAPP: I'd just add to it, too, as we try to think down the road, and if truly we want to see smart grid, for example, and this integrates into a door, or people who are at home can connect through a medical sensor and have their physician read it, these seem like things that everybody ought to have.

MR. LIVINGOOD: And I would maybe say two things, I have two thoughts here; one would be, you know, please refer to the filing that we made in response to the -- we put a lot of thought into some very detailed year over year, you know, what do we think the quantitative speeds should be and how should they change, and so that's number one. I think, you know, we tried to put a lot of thought into it and we know that's a tough problem for you.

The second would be, you know, it doesn't matter, at the end of the day, we can all build collectively a brilliant network that's super high speed and passes a lot of homes, but I think the plan still has to address the fact that they're going to be a lot of people, and I think the PEW Study is interesting on this point, that for whatever reason, choose not to subscribe, whether they don't feel it's relevant to them, they're not computer literate, or you know, a variety of other factors, and I think those are important to take into account, too.

MR. CURTIS: If I could just add to Stagg's filer request, which I completely agree with, that would be extremely helpful. It would be also helpful if, instead of having, you know, your point of view on what you would think of broadband as being in 2009, some sort of, you know, growth curve on how this evolves over time, you know, it doesn't make a lot of sense to think about doing something today that's going to quickly, you know, go out of --

MR. BURKE: Perhaps one way to think about this, and I don't know this as a final answer, would be, rather than try and come up with some actual numbers, would be to base it on some sort of parody of the areas that are currently being served. So we have a range of services that are out there today that people can pay higher tiers for, and with the concept of people who are currently unserved not being disenfranchised or having this digital divide, to have them at least have access to, you know, a popular -- one of the lower tiers.

I would also say that when cable modem service first rolled out, and there were some surveys done of users to find out what they wanted, and you know, did they enjoy the higher speed than dial-up, what they found was, is that most people signed up for it because they thought they'd be getting the higher speed, but the main benefit was actually always on. And so when you start talking about some of these smart grid applications and medical monitoring and telemetry, they're very modest, very low speeds, and they don't even really need to be real time. If you can provide low speed, always on, hundreds of kilobit per second service, you immediately enable that aspect of it. And then, you know, the web surfing, you know, is probably where the lower tier of services are today, and that maybe should be where you draw the line, and every year take a survey and see where it is and try and, you know, set that threshold higher.

MR. NEWMANN: Yeah, let me -- great point. And Rob raised -- we need to think about

how to quantify the notion into a viable definition. One of the bigger mistakes I made when I was at the FCC before, and I made plenty, was, Dale Hatfield and I were the ones who came up with that infamous 200 kilobit per second definition, but to defend ourselves, that was 1999, and we defined it as a viable definition. Unfortunately, we should have said viable definition with at least a 30 percent cager. I never dreamed it would still be 200 kilobits per second, you know, a decade later. So how do we think about that aspect of the definition?

MR. CURTIS: If I could just pile onto one thing. Stuart, I love the idea of looking at the parody, that's another way of thinking about it. And as you all think through, hopefully, and help us think about this, one other thing I'd throw on the table is, is some part of the relative parody an international benchmark?

Is it important that, you know, we keep pace? We make sure that currently unserved communities today keep track with other served

communities in this country; is it separately important that we keep pace with, you know, let's call it our developed peer group? And if so, how would you guys think about, you know, that factoring into the way you think about broadband?

MR. YOUNG: I'd just like to say in defense of Stagg that the 200 K, you know, has gotten a lot of criticism, but in fairness, it's still a useful speed for a lot of applications, and a ubiquitous always on 200 K capability would be very beneficial for smart meters and those sorts of things. So I don't think you want to dismiss the lower end of these things and say, well, that's not broadband or that's not what we're talking about. The whole range is of value, I think.

MR. BURKE: It is of value, but you have to -- we really need to identify where the natural progression of each of these things is, right. Medical monitoring today is a very low band width application, but the natural extension of this is a high definition interview with my doctor at a

given point in time, right.

Now, to the extent that, you know, clearly, we have to have an evolutionary path to this, but from a definition standpoint, I want to make sure that we're not losing sight. You've got to establish that goal, we're either going to the moon or we're not, right, and we establish what that is, and then we back our way down to either penetration rates over the course of time, where we have to hit those milestones, or you know, other levels that maybe even regional in nature, right.

But I think that the mistake in this whole line of thinking is that unless you establish what that ultimate goal is by looking forward with regard to these natural applications, then you kind of -- you tend to get into these increment steps which are not necessarily I think what the most cost effective, nor the most efficient way to ultimately get where you want to go.

MR. KNAPP: David.

MR. BURSTEIN: Yeah; there's lots of different ways of looking at it. And again, I learn from the engineers, I'm not an engineer, so I look at what's practical. The answer to Rob's question of whether you'll get to international, beside having to keep pier, I don't give a damn about link tables, but when I look internationally and I see Japan has done this, and France has done this, or Verizon has done this, and AT&T hasn't, or Comcast has done something that Time Warner hasn't, I say it sure as heck proves that it's possible to build FIOS, and it is possible to deliver 50 meg DOCSIS to half your homes in three years, and that the goal for the U.S., when minimums have some place, should also be to look at what's the best and get us as close as we can get to it, related to what's there.

When you're asking the minimum question, that's a very important question for about two or three percent of the U.S. population. It's also -- yeah, and it's ignoring the factor that affordability manages, but that's a whole another

discussion here. A lot of poor people can't get it because they're poor. Everybody on this table know that's part of it. But what you're missing when you talk the minimum there is what service are you giving to 95 or 98 percent. Where I think the minimum should look very different, not sitting there, is it 256 K or one meg or two meg, which we can and easily can give to 100 percent of the U.S., technically and economically, although the latency for two percent on satellite is a problem, okay, it's absolutely doable.

The question is, what's good for the American people? I think we can all agree that having a better internet is good for us all. So I look at not what's the bare minimum, but what's the practical thing economically at low cost to deliver. Stuart, how fast were your cable modem downloads in 1999?

MR. LIPOFF: I think I was probably getting one and a half megabit per second service, something on that order.

MR. BURSTEIN: Well, then you were going

to the wrong server, because other folks were getting ten megabits just fine, that's what the network was designed to give, and was selling, of course, most of the country in 1999.

MR. LIPOFF: I have a slow computer.

MR. BURSTEIN: It's his computer, it's not his internet. But the reason I'm bringing you to that is, it is absolutely practical from the cost perspective to give everybody ten megabits now except for maybe five percent of the country who have distance and other problems. The second thing is that the speed has nothing to do with the price in a competitive market. This is something that the U.S. keeps getting confused because we only have two competitors.

You go to France and Japan, everybody gets the maximum speed they can get on their line. Everybody in France gets up to 25 meg at the same price, because it turns out, all this talk about speed is marketing. The cost of delivering broadband, 90 percent is the cost of getting that line in the home, whatever the speed is.

So in a competitive market, nobody is selling the slow stuff, they're all giving the basic speed that the line can have, which is up to 25 meg, which may be only two meg, and 50 meg shared, which is -- goes down to 30 meg three percent of the time, which is about what DOCSIS 3.0 is right now, but we don't have good numbers on that, that's a guess. And I wish we would get some numbers out of Comcast. And that when you can look at what is possible, what is cheap, by looking at real networks and real economics, I want the policy people to get that to every American that they can, and that's a much more interesting way for, I think, to look at it. How can we really get something great for everybody in our country?

MR. KNAPP: I have to apologize to -- I must have eight different emails here, all on this same subject, and I can't ask all these questions, but they're all variations of the same theme that we've been talking about, things like the transparency, making information available to the

consumers, should there be different, you know, how do we define this level of service and so forth, and as Stagg and Rob have said, you know, this is really what we're charged to come up with, so you've got a homework assignment from Stagg, and don't forget it. The only thing he didn't do is give you a due date.

MR. NEWMANN: Next week.

SPEAKER: Where does -- Columbia supposed to get some of the state over to the FCC?

MR. KNAPP: Did you have any additional questions? I mean I still have some, but -- Walter or Ron.

MR. JOHNSTON: One question I will ask; all these networks are fiber networks with some different access technology. One of the things I've heard, both in the first and the second panel session, is an expectation that the need for speed keeps growing, I think that was the consensus of the first panel, I think I heard a lot of that, maybe it's not the same consensus on this panel. How important is it to move fiber closer to the

residents, and what could be done to make that more attractive?

One of the concerns I would have at listening to you people talk is that some of the more economic technologies, especially in the rural areas, might also be capped at a speed that's not upgradeable, so what recommendations would you make in that regard?

MR. YOUNG: Well, I think, you know, that was the primary driver for us to go to fiber all the way to the home. It was sort of the recognition that, you know, we would be upgrading the network, trying to push that fiber closer and closer to the home.

MR. JOHNSTON: Well, any closer, you're in my bathroom, so I think you're off the hook.

MR. YOUNG: Well, no, but anyway, so my point -- my only point there is that, in recognition of that, by bringing the fiber all the way to the home, it makes it easier to upgrade to whatever the ultimate demand is. And we don't know what it's going to be, but we know that it's

going to continue, you know, at relatively the same pace that it has been. So, you know, that's why getting the fiber to the home was so important to us.

MR. BURKE: Well, I think there's a theoretical and a practical answer to your question, as well. I think that, you know, if want to hit, if we accept that mobility is, indeed, you know, a natural need and service demand going forward, and you want to hit those LTE speeds that are meaningful, right, you've got to have a very, very deep fiber network to be able to do that, okay.

And so to the extent that -- just on a practical basis, as we take natural applications for the very near future, right, that's going to have to be a fundamental cornerstone of some of this policy.

The more theoretical aspect of this is, I'm going to go back to our own experience with, as I mentioned before, hundreds of these rural providers who have gotten fiber deployed very

effectively in their areas, is that there seems to be a very close relationship, that the closer you are to your subscriber, okay, and I'm not talking about -- I'm talking about emotionally, all right, the closer you are to your subscriber, the more likely it is that you deploy a very high speed and probably fiber rich infrastructure to that subscriber, and that's because a direct line of feedback between the consumer and his wants and desires and needs and the service provider is very closely linked.

So this body can think about the ways, and we're all in this together, right, to identify how we can basically broaden the horizon for return on investment for these companies, and to allow them to look beyond the short term, as well as to get them more in touch with their subscriber base. We're going to naturally lead ourselves to what is ultimately a position in which we're deploying very high speed broadband in these areas, because the subscribers want it, there's no question about it.

MR. NEWMANN: Geoff, just to follow up on that, first of all, you're commended for putting some real numbers up on your charts. To help us understand --

MR. BURKE: Walter encouraged me to do that.

MR. NEWMANN: Yeah, and I encourage -- I'll give two homework assignments out here; you get the easy one, Geoff, the rest of you, if you could give us similar numbers, that would be great. And then with that, I think it's very important that we understand the assumptions. For example, building fiber out in a rural area where the town is clustered, and therefore, you have high linear density, and you have telephone poles, is hugely different than building fiber out where it's on a lava bed with low linear density, to go to the worst case. So helping us understand at a much deeper level would be most useful.

MR. BURKE: I have a lot more numbers then that, I'd be happy to share with you, too. Those numbers -- they were aerial, by the way.

MR. NEWMANN: We'll be making the appointment.

MR. BURSTEIN: Let me give the audience some of those numbers that aren't all of them, but it's a good working thing, and why I feel that a lot of things I'm seeing out there are too high. His number of 800 per homes past is online.

Every number I'm hearing around the world is 650 to 1,000 for fiber, with two key distinctions, one, if you go underground that adds something to the cost, and two, which is huge, is how much fiber you have to run per home, because the working cost in the U.S. is $20,000 per mile. So in order to get to five customers, you have to run a mile of fiber, that's $4,000 a home.

For the purpose of policy, that means on anything we're looking at to see if the cost is reasonable, we want to see how many miles of fiber it takes, if it's huge, then you have to look at the numbers of $3 and $5,000 that are coming into the broadband thing. DSL cost about $50 to $125 for the basic gear. The number from AT&T to bring

25 megabits to most of their network is $300 per home.

As you get into rural areas, it gets a little bit higher, but not that much higher, so that's a ballpark. None of those numbers include the cost of sending somebody to your house and hooking up all your TV's, which is somewhere between $300 and $700 per, which is why when the pros talk about it, we talk homes past as one thing and homes served with everything complete is another.

But it's very useful to look at that number. DSL should be in the order of $2 to $500; fiber should be in the order of 1,000 to 3,000, and in large networks that are not spread out, much closer to 1,000. And cable, this is the amazing number and why DOCSIS is so interesting; if you have the cable in place, it's already there, 96 percent of the U.S., to upgrade to DOCSIS 3.0 is less than $100, probably including the upstream, but I don't have a hard number on that. And if you're the three percent who are

crucial to the unserve, who may be these old analog 550 megahertz, how much would it cost to upgrade per user, an analog system to basic digital?

MR. DEPIETRO: Well, these systems have anywhere from call it 1,000 to 10,000 subs.

MR. BURSTEIN: Okay. How much per home?

MR. DEPIETRO: We're talking about a total capex of anywhere from 100 K to 500 K to get them up and going.

MR. BURSTEIN: And so we're talking less than 500 a home to get 50 meg out there on cable if the cable is in place, which is why the cable is such an interesting alternative no matter how great fiber is, and it's a hard question.

MR. NEWMANN: That includes the fiber out to the HFC point, the amplifier --

MR. DEPIETRO: That's basically head end and CPE.

MR. NEWMANN: So now we have to have all the --

MR. DEPIETRO: The assumption here is

that the plant --

MR. NEWMANN: -- the new amplifier, the fiber fee --

MR. DEPIETRO: Those are extra, right.

MR. NEWMANN: Which is why 1999 was $1,500.

MR. DEPIETRO: Right.

MR. LIVINGOOD: Just to add a couple of things to that, I think, you know, I would just recommend that you be careful not to be sort of overly prescriptive with the technology solution. You know, there are a lot of different types of facilities out there today, whether it's copper, coax, fiber, or wireless, that I think can meet the need, you know, for broadband in the country, and so I think that's important.

And to sort of Dave's point here, I don't think the objective to see who can spend the most money, it's to see who can do this cost effectively and quickly. And I think, you know, whether it's the DOCSIS or other network, there are a lot of networks out there that can do this

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very quickly and that are in place today.

MR. CURTIS: One other thing to add to the homework is, and we often get caught up in talking about capex a lot, which is an interesting number, you know. Too infrequently I think we hear about the opex side of this. So as you're thinking about, you know, answering Stagg's question about the numbers, and you know, love to know, you know, particularly from those of you that have experience with both or all three, or you know, if you want to throw LTE in, all four, 3G, let's make it five, opex differences that matter. You know, cost of maintaining the copper plant versus cost of maintaining fiber versus cost of maintaining the HFC, all of that, the labor intensity, you know, at least goes to sustainability, and part of thinking about the total return on the investment, which we'd love to understand better.

MR. BURSTEIN: You want a ballpark? Look at $5 to $10 per month per subscriber for any broadband we're talking about. Fiber has fewer

truck rolls, but that's not the main factor, so it's a little bit less. Rural doesn't add that much unless it's really extreme, because you have less traffic getting to the homes, even if they're further apart, and usually have lower pay rates, so that why, yes, there's a variation in your thinking, it turns out not to be huge.

That number on broadband comes from providers around the world, it's not my making up, it's my asking people what they're spending from internal, and that is not a fully loaded, overhead cost with return on original capex built in, that's an actual operating cost, and it varies enormously, not on technology or anything in Washington, but whether the operator is competent or not. A lot of them are pretty lousy and some of them are really good, and there's a huge difference in cost.

MR. BURKE: Well, there is a big difference, though, operationally, looking at the more rural you get is the reach that these visual technologies have, right. So, for example, when

you're talking about the difference between running an extended reach GPON or an active Ethernet, you know, 40 and 60 kilometers, with nothing but passive splitters out there in that network, right, versus the alternative, which is laying pads, putting in more equipment, having the active empowered and those sorts of things over time, as you get increasingly rural, and you get increasingly environmentally challenged, all right, are the, you know, those end up being very, very real costs. I just wanted to temper a little bit of that, as well.

MR. BURSTEIN: Help me with the number there, because I absolutely agree. I said extreme rural is more. About what percent are we talking about who's so extreme rural that it really changes the ofex that you're thinking about, 40 kilometer runs on a regular basis. My sense, it's somewhere between one and five percent, but I don't have any hard data on that at all.

MR. BURKE: Well, realistically, I mean let's think about even the movement of -- or the

placement of a cabinet at a 20 kilometer mark that actually -- at the -- somewhere -- that then goes out and feeds a number of different communities out beyond that, any one of those could easily be a 50 plus thousand dollar endeavor just from a capex perspective, not to mention the overall ongoing maintenance power center, right.

We often see with our customers that each one of those opportunities is an initial $50,000, plus they project double that in terms of ongoing operational cost over say a five year time frame in those environments, and often times they multiply, because each time you're able to collapse that entire network into one central location, you're taking all of this cost out of that network.

MR. BURSTEIN: And it's desperately hard to get these numbers, because operators certainly don't want to share them publicly, which is why I don't give you sources on many, because they're only going to tell me so far off the record I can't use them here, because I've been asking

loads of these questions, I'd love better numbers.

MR. BURKE: Well, let me give you one -- it's kind of funny you say ample, but the only time I've ever had a room full of operators stand up and applaud was, I actually introduced a product last year in which we had basically extended the reach of GPON, basically double from what it was, from its current standard out beyond that, and basically everybody in the room stood up and applauded that, because they knew what impact that would have for them in terms of their ongoing capex and ofex.

Now, we can get into details to quantify that, but just to give you a sense of the types of impact that has on these folks in terms of their ability to meet the services that are being demanded, plus their need to go out and get those services deployed.

MR. LIPOFF: Let me suggest, while you're collecting numbers, don't forget the revenue side, as well, because it's the revenue that actually is advertising that capex, and, in

fact, what you really want to look at is, you want to look at the incremental capex to take you from whatever the baseline is and the incremental revenue associated with adding that.

So if you're starting from DSL as a technology, you're probably assuming there's already a voice telephony service there, and the question is, what's the incremental capex you have to add to enable that? Can you put the -- do you have to move the DSLAM out into the environment or can it stay in the CO? What additional benefits can you provide, just high speed internet, or are you going to provide video? So each of these start at a different place.

MR. CURTIS: I think speaking for Stagg, and certainly myself, we would love to sit down and understand your PNL's, this granular level all the way through as you would, you know, try to avoid asking it that way, but, you know, the more detail, the better. I'd love to see the revenue table.

MR. KNAPP: Well, this has been a

fantastic panel, too. And I really want to thank all of you for participating. Another case, we probably could talk another couple hours. But we'll follow up with you, and thanks very much. We're going to break for lunch, and we'll reconvene on mobile technologies.

(Whereupon, the PROCEEDINGS were adjourned.)

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I, Carleton J. Anderson, III do hereby certify that the forgoing electronic file when originally transmitted was reduced to text at my direction; that said transcript is a true record of the proceedings therein referenced; that I am neither counsel for, related to, nor employed by any of the parties to the action in which these proceedings were taken; and, furthermore, that I am neither a relative or employee of any attorney or counsel employed by the parties hereto, nor financially or otherwise interested in the outcome of this action.

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